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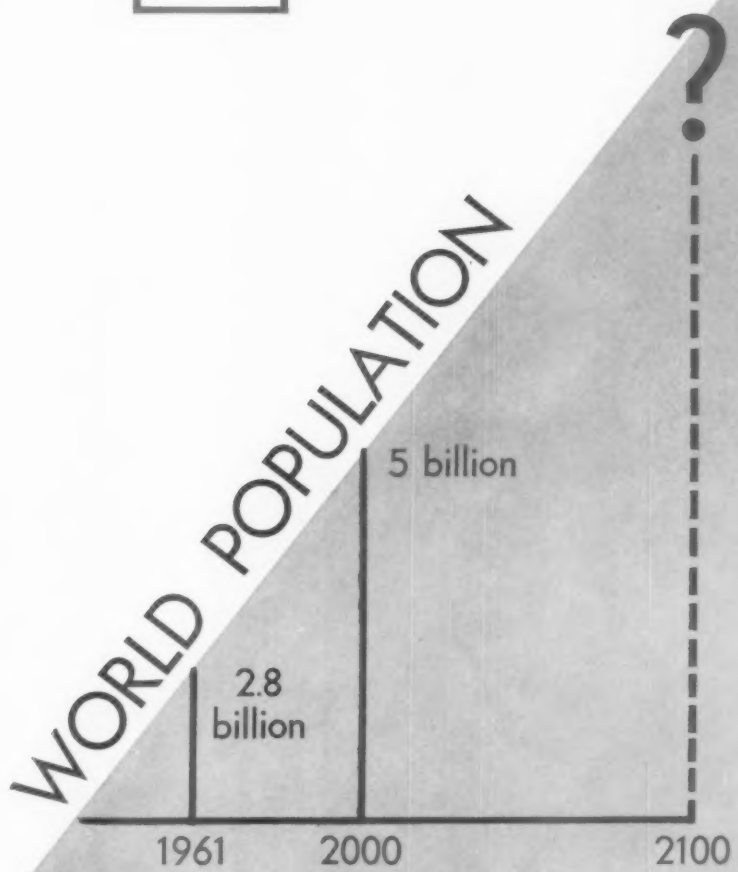
FT food technology



ATOMIC WAR?

FOOD THE CENTRAL PROBLEM?

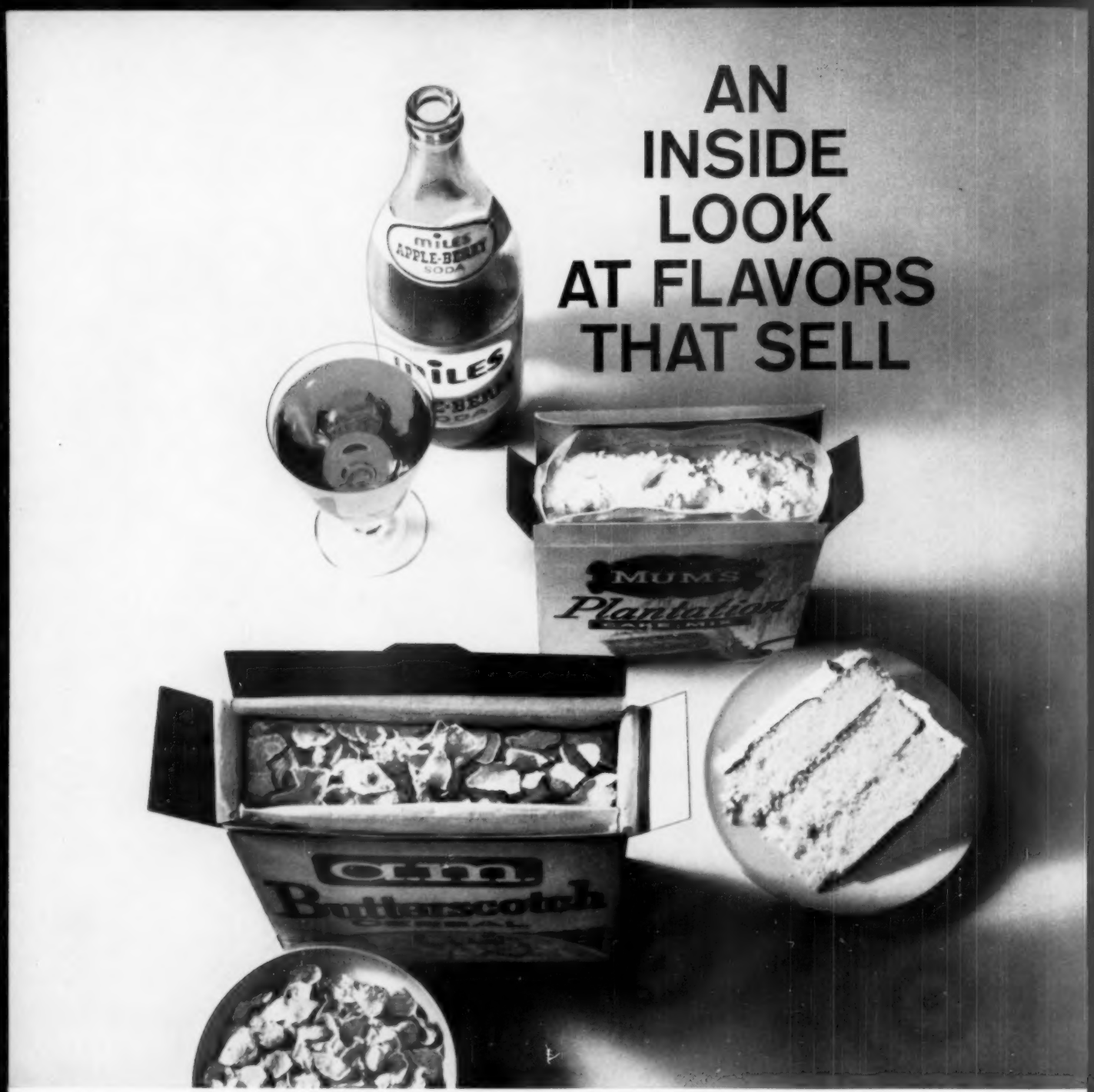
THE PILL?

TOO MANY MOUTHS?

ENOUGH TO EAT?

See Page 8 ⟶

JOURNAL OF THE INSTITUTE OF FOOD TECHNOLOGISTS



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food technology

AUGUST, 1961
Vol. 15, No. 8

features

Growth and Importance of IFT Developed on Firm Base 5

World Population: The Great Question 8

The "Multiplier Effect" of Frozen Food Technology on American Life 14

Translation of Paper by Soviet Scientist 27

A Russian Progress Report on Use of Radioactive Isotopes 42

research

Studies on Frozen Fish. II.
Some Chemical Changes Occurring During Frozen Storage 347
P. L. SAWANT AND N. G. MAGAR

The Effect of Pure-Culture Inoculation on Fermentation of Cucumbers 351
CARL S. PEDERSON AND MARGARET N. ALBURY

Effect of Active Carbon on the Storage Stability of Irradiated Meats 354
GERALD D. GERNON, JR., FRED J. KRAUS, AND MAURICE P. DRAKE

Ultramicrodetermination of Mercury in Apples 357
MORRIS B. JACOBS AND LEONARD J. GOLDWATER

Experiments on Preservation with a New Ice Containing Glycol Diformate and Sorbic Acid 361
SOCRATES KALOYEREAS, R. M. CROWN, AND C. S. McCLESKEY

Chemical Composition of Potatoes. II.
Relationship of Organic Acid Concentrations to Specific Gravity and Storage Time 364
J. H. SCHWARTZ, REBA B. GREENSPUN, AND WILLIAM L. PORTER

Effect of Room Temperature vs. Refrigerated Storage on Quality of Canned Fruit and Vegetable Products 367
AARON L. BRODY AND KARAKIAN BEDROSIAN

The Effect of Internal Temperature and Time of Cooking on the Palatability of Pork Loin Roasts 371
NANCY L. WEBB, N. B. WEBB, DENA CEDARQUIST, AND L. J. BRATZLER

Maple Syrup. XVIII.
Bacterial Growth in Maple Sap Collected with Plastic Tubing 374
H. A. FRANK AND C. O. WILLITS

Research Note
Thin-Layer Chromatography—A New Analytical Technique With Potential Applications to Foods 378
MAURICE E. STANSBY

departments

Advertiser's Index 47
Book Reviews 36
Books 38
Bulletins 38
Classified Advertising 47
Coming Events 34
Expansion News 40
IFT News 13, 34
Industry News 45
International Food Technology 33
People 40

From beefsteak to biscuits . . .

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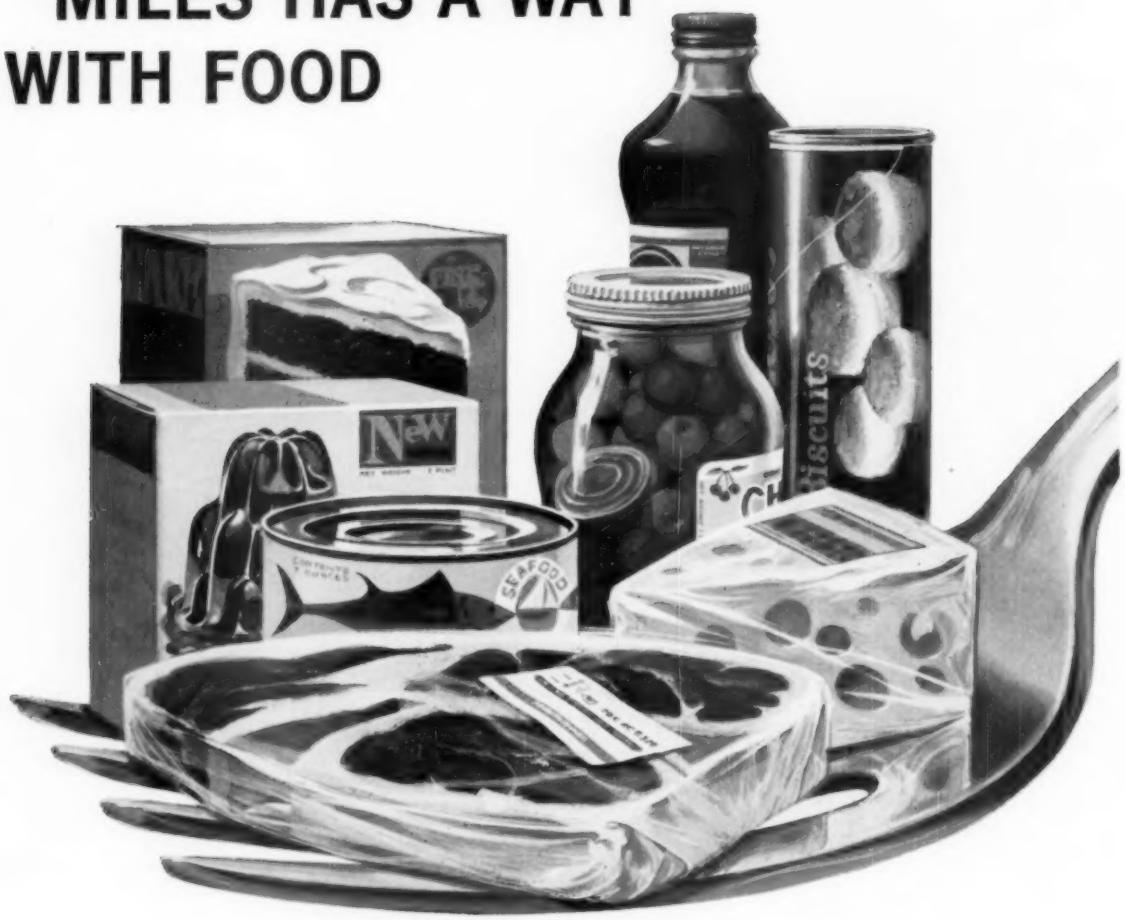

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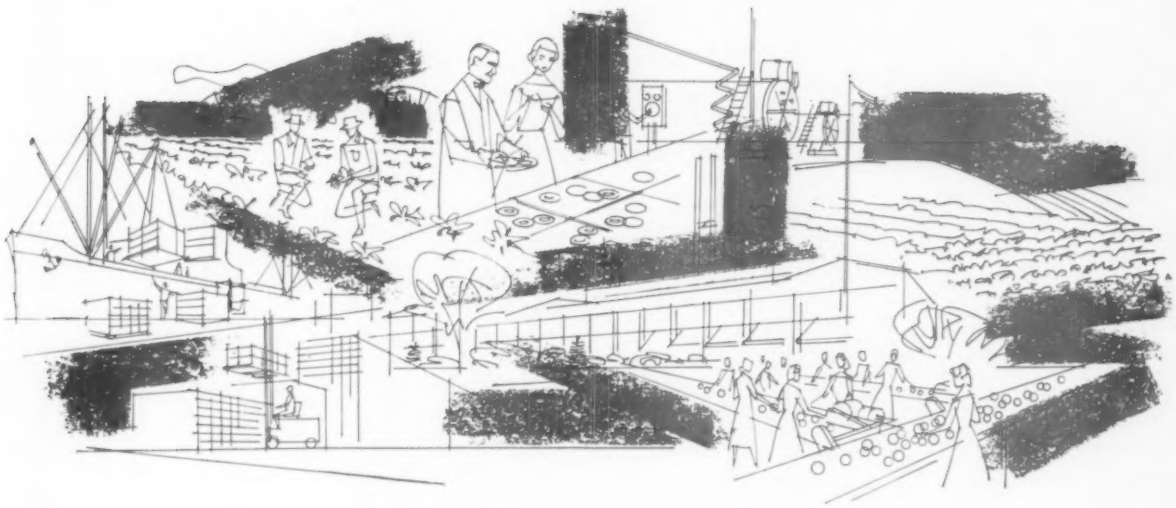
Growth and Importance of IFT Developed on Firm Base



Early Expectations Bear Fruit

The time is June, 1939.

The place is Cambridge, Massachusetts.

In a cluttered dormitory room two men put the polishing touches on a section of a constitutional proposal they would make the following day. At another table a third man pored over his records.

Suddenly there was a question:

"How big an organization do you think this will be?"

The reply was immediate and definite.

"Oh, about two hundred at the maximum."

The third man, having overheard both the question and the answer, exploded in protest.

"Two hundred! If we don't go to 400, we shall be a failure!"

* * *

The question was raised by B. E. Proctor. The estimate of 200 came from L. V. Burton and the explosive protest that failure would result from a membership of less than 400 was made by G. J. Hucker.

* * *

"We" are not a "failure!" "We" are the Institute of Food Technologists, and at this writing there are more than 6,200 paid members of this professional society, which came of age much earlier than its founders predicted and which concluded its 21st Annual Meeting in May, 1961—just short of the actual date of its birth, 22 years ago.

Today the members of the Institute of Food Technologists can be justly proud of the many contributions they have made to the growth and technological advances of the nation's mammoth food processing industry—one that accounts for over 8 per cent of all industrial production.

IFT members have been responsible for the developments that have produced the increasingly popular convenience foods and for a general up-grading of the public's food tastes. One yardstick of the growing popularity of the convenience foods: frozen-food production of about 7½ billion pounds in 1960 was nearly four times the output of 1950.

Total food expenditures this year are expected to top $78 billion, up from about $76 billion last year. Some of the growth, of course, is attributable to the increasing population, but much of it is also due to the thousands of new products that have come into being since World War II. About half of the products on the grocery shelves today were born in, or improved in, the laboratories and minds of the food technologists during the past decade. The average supermarket carries some 6,000 items now, as against a mere 1,500 at the end of World War II.

The magnitude and importance of the food industry is sometimes incomprehensible. Last year the industry spent $100 million for research and development, and much of that vast sum went to food technologists or people in positions closely related.

Let no one feel the food technologist unimportant in his contributions to the general welfare of either management or the consumer. The contributions have been and will be invaluable for all time to come.

For historical purposes, the Institute of Food Tech-

nologists came into being at the second M.I.T. Conference of Food Technology, in Cambridge, Mass., on July 1, 1939.

It came about not as a fortuitous happening, or a sort of spontaneous generation, but as a logical outgrowth of the thinking and actions of a considerable group of individuals who became its sponsors.

Fundamentally, there was the conviction that such an organization could help management, the growing food industry, and the general welfare of the whole population.

There had been a suggestion that the fledgling organization be called the Society of Food Engineers. Objections to this designation were made on several counts since the majority of those present, and of food workers in general, were trained chemists, bacteriologists, or nutritionists, rather than engineers.

The name "Institute of Food Technologists" was eventually selected since this broader term includes management and the other branches of scientific training implicit in the food industry, as well as engineering.

The record will make it clear that IFT was not "born to blush unseen, and waste its sweetness on the desert air." Many firms in the food industry would be proud to point to a growth even comparable to that of the IFT.

In retrospect, however, there is cause for wonderment at the growth, the importance, and the popularity of the Institute of Food Technologists, because 10 years elapsed before the establishment of a central office of the Institute, or an Executive Secretary to give direction and act as a clearing house for Institute business matters. Obviously the growth came as a result of the firm base on which the Institute was first conceived, and through the dedicated efforts of various members in this country and abroad.

At the 21st Annual Meeting, in May, 1961, provision for anticipated expenditures of some $277,000.00 was approved. That is a far cry from the budget of $2,500 recommended for the fiscal year of 1941-1942, which provided $1,500 for publications, $400 for office expenses, $300 for secretarial assistance, $150 for travel of officers, and $200 for the Annual Meeting.

The record is not clear as to the number of Founder Members, but the most recent count, shortly after the 21st Annual Meeting, is quite clear. On the rolls are more than 6,200 paid members. (It is important to mention that they are *paid* members, for in the early days there were many applicants who never got around to paying, and so never actually became members of the Institute of Food Technologists.)

The Membership total includes 195 in Mexico and Canada, and 515 others lumped in the classification "other foreign" . . . surely enough to indicate the scope and importance of the IFT.

Similar evidence of the growth and the importance of food technology is seen in the international scene. The IFT journal, *Food Technology*, the first issue of which appeared in January, 1947, had, by the time of the 1961 Annual Meeting, a total monthly distribution of 7,827 copies, many sent to paid subscribers in foreign countries.

But a flash-back seems in order. On that momentous date, July 1, 1939, the first officers of the Institute of Food Technologists were elected. They were:

President—Samuel C. Prescott, Massachusetts Institute of Technology, Cambridge.

Vice President—Roy C. Newton, Swift & Co., Chicago.

Secretary-Treasurer—George J. Hucker, N. Y. Agricultural Experiment Station, Geneva.

There were many equally capable and dedicated officers and executives who followed that pioneer group into positions of responsibility in the still-growing years of IFT, but it seems appropriate to record these names in this short history of the years that brought IFT to maturity . . . Space limitations, however, prevent giving adequate credit to all.

This group lost little time in plunging into action, and the first Council Meeting was held in Pittsburgh on October 16, 1939. It was termed a "long and important session," and in review justifies that description.

Among the earliest actions, and one that has contributed so greatly to the present stature of the Institute of Food Technologists, was the decision that "If the IFT is to become stable and respected, much care is essential in approving the qualifications of its applicants for membership." It was there that it was decided that the constitution should be "rigidly enforced insofar as membership is concerned."

Those principles, followed to this day, resulted in the election of 359 members and 34 affiliates from a list of applicants submitted by the Secretary. (Then and there, Burton's most optimistic estimate of membership was topped—and Hucker must have realized that failure had been averted!)

The Council members authorized the Secretary to establish a News Letter to go to all members at appropriate intervals, and accepted an invitation to hold the first Annual Meeting in Chicago, June 16–19, 1940.

That first meeting, said to have "set a high standard for IFT conventions," voted to establish a Publications Committee to consider the establishment of an official journal, and reelected all of the officers.

In January, 1941, with war clouds barely visible to most Americans, Council members took note of the danger and set up a National Defense Committee to serve the Armed Forces in matters pertaining to food and nutrition and to cooperate in mobilizing men who might be commissioned to various services requiring trained personnel. The foresight of the Council was also apparent in the decision that made the main part of the program for the Annual Meeting at Pittsburgh consist of four symposia dealing with food technology as it related to national defense . . . all this some 11 months before Pearl Harbor.

A similarly important action of the Council recognized a petition of the Chicago group and designated them as the pioneer Regional Section of IFT.

The second Annual Meeting, held in Pittsburgh in June, 1941, granted a charter to the Northern California Section (No. 2), heard the presentation of the

Chicago Section to establish the Nicholas Appert Medal Award, and approved the $2,500 budget mentioned earlier.

The 1942 meeting heard a report that IFT had over 1,100 members and witnessed the presentation of the first Appert Medal, awarded to Professor William V. Cruess, of the University of California.

Many organizations, professional and otherwise, failed to survive the war years, but seemingly nothing impeded the growth of the IFT, and much of the work done by individual members contributed to the growth that came in the post-war years.

Notable in the latter category is the "missionary" work done by Dr. L. V. Burton, a past president of IFT, during the period he served in Australia. As a result of what he, and others, did to interest food technologists in that country, Australia Northern, Section No. 19, and Australia Southern, Section No. 23, came into being.

By the 1946 Meeting, the Institute had a membership of 1,859 and "was in a sound position financially." In the same year the Council approved the proposal for an Achievement Award to be given the company that in the opinion of a jury had "made the greatest achievement in food technology."

The Council also voted to establish the journal, *Food Technology*, with C. Olin Ball as Editor-in-Chief, a board of associate editors, and G. J. Hucker as Managing Editor for the first volume. The first number appeared in January, 1947, the start of a permanent journal of the Institute of Food Technologists and one that has grown to a point of numbers and influence that easily justifies the fondest expectations of its founders. Two years after the first issue appeared, *Food Technology* was the leading journal in its field, with a circulation of more than 3,000 (less than half of what it is now).

A milestone of 1949 came when Col. Charles S. Lawrence was employed as a full-time Executive Secretary and later installed Chicago offices at 176 W. Adams, still the address of the Institute.

It is not an easy thing to document the increasing growth and importance of the Institute in the years that followed, but the record shows there was such growth. What it does not show is the manner in which top management has come to look to food technologists for vital help in keeping their products appetizing, nutritious, and, equally important, profitable.

At the same time there has been a constant striving to keep the membership of IFT at high standards of professionalism, and significant progress in the administration of the Awards program, and in the promotion of increasing interest in food technology through work with schools and science teachers.

Neither individuals nor organizations achieve maturity overnight. Increasing stature comes with age. The Institute has the stature and looks forward to achieving even more. After all, the Institute of Food Technologists is, in age, just past 21.

Now there is a new "team" guiding the destinies of the group which has just reached its majority. President Harold W. Schultz will direct the destinies of IFT until the ascension of Dr. John M. Jackson to the presidency, next spring. A new Executive Editor, in the person of Dr. George F. Stewart, is at the helm of IFT's two publications, *Food Technology* and *The Journal of Food Science*, and at "home base" in the Chicago offices is Calvert L. Willey, recently designated Executive Secretary for the Institute of Food Technologists.

With this leadership it would appear that the 21st Annual Meeting was not only a time when the Institute "came of age" in the numerical sense, but was also Commencement Time!

Col. Lawrence | Dr. Schultz | Dr. Stewart | Mr. Willey

World Population: The Great Question*

WHEN MAN depended exclusively on hunting for his living, the land could carry only about one man per square mile, but when agriculture was invented, five times as many could be supported, and the population gradually increased to fivefold. Later came another revolution, the invention of city life, with the possibilities of trade and the division of labor, and again numbers multiplied by five.

These revolutions happened in ancient times, and in each case it took thousands of years to build up the numbers in this way, but the new Scientific Revolution has already far exceeded them. Thus, in nearly 2,000 years the 200 to 300 million people at the start of the Christian Era merely doubled. But the 500 million of 1750 multiplied by five in, not thousands of years but only two centuries, and the number of human beings is now over 2.8 billion. It is practically certain that in less than 40 years the number will be doubled again and there will be well over 5 billion people in the world.

ATOMIC WAR EXAGGERATED

In making predictions it is of course easy to be wrong, but nothing can really alter things much. Thus the annual increase of world population is nearly 50 million, whereas we can fortunately count as a rare tragedy a famine or a war which kills 10 million, a number made up again in less than three months. Even the effect of an atomic war can be exaggerated from the present point of view. Such a war might perhaps kill a whole continent of people, say 300 million, and this would be far and away the greatest catastrophe that has ever hit our race. But it takes only six years to catch up this number again. However, though man has often shown himself a not very wise animal, there are limits to his folly, and we may reasonably hope to escape that particular tragedy.

RAISE TV SETS

If evil effects are not going to upset the predictions of the demographers are there any good effects that might? A few years ago many people would have answered that there were, pointing to Western Europe, where the annual increases are only a fraction of a per cent, instead of the two or more per cent in less developed parts of the world. This they attributed to Europe's prosperity; people who could get a motor car or a television set found them much preferable to the having of children. So the argument then went that we must contrive to raise the rest of the world to this level of prosperity, and as each country attained it, its rate of increase would drop. We should end in a world-wide millenium of motor cars and television sets with just enough children to keep the population constant.

It cannot be. The most prosperous country in the world, the United States, is among those increasing in numbers most rapidly. It is not prosperity that has limited the increases in Europe, but crowding. One day the United States may reach a density of population comparable with that of Europe—and that, if anything, will be what stops America's increase.

THE PILL

Those who fear the consequences of the population explosion claim one other cause may upset the predictions, the extending practice of birth control. Present methods are used by a comparatively small fraction of the world, and they are unsatisfactory and expensive. Biologists suggest that even within a few years something better might emerge. But that is only the easy part of the problem. To have any real effect it has to be used on a world-wide scale, and this means altering the most intimate part of the way of life of something like a billion people.

We are practically certain, therefore, to have over 5 billion human beings by the end of the century.

ENOUGH TO EAT

Can they hope to enjoy anything like the prosperity of the present time? The first question is whether they will get enough to eat. It is not known as well as it should be that even now more than half the world —some say two-thirds—do not get enough to eat. They are not all dying of famine, of course, but they are getting 10 to 20 per cent less than the calories they need, and this necessarily makes them incapable of working so hard, and it is apt permanently to weaken their health. If that is so even now, what are the prospects that when our numbers are doubled there is any hope that we may still be able to keep so many people alive?

MODERN FARMING

It seems to be the general opinion of the experts that it could be done without any revolutionary transformations of our agricultural systems. Why can we not teach the efficient methods of the average American farmer, which are something like 10 times better than those of his far more numerous counterparts in less fortunate lands, to the rest of the world? We shall certainly try, and no doubt things will gradually change in that direction, but it is not going to be easy quickly to convert the whole manner of life of hundreds of millions of men.

THE CIRCLE ROUND

There is in Nigeria an area of country quite suitable for good agriculture, and not very thickly inhabited. It seemed a suitable place, a few years ago, to change over into modern methods of agriculture. A great deal of capital was provided so that roads

* Taken from an address given by Sir Charles Darwin at the Charter Day ceremonies of the University of California, Davis, March 22, 1961.

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could be built and tractors and bulldozers bought, and the people were taught how to use them. What went wrong was the complete upset of the way of life of the people. The local system of land tenure had developed with small individual farms, often with agriculture shifting from place to place every year. This could not easily be changed to a system of large acres all controlled in an organized scheme, because that involved the sacrifice by many people of their established rights. Then there was an unexpected trouble arising from the training of the mechanics who were to drive the tractors. They naturally needed a lot of training, and this built them up into a kind of new aristocracy, but there was already an old aristocracy of the tribal chiefs, and these resented the creation of the new one, so that there was perpetual friction between the two groups. Then again, to work the new farms there was need of more people than the local inhabitants, so that men had to be brought in from outside; but it proved that the ones who were willing to come were mainly men who had been failures in their original homes, and they were apt to fail again. As a result of all these troubles the final production of food proved to be hardly greater than it had been under the old methods.

FOOD THE CENTRAL PROBLEM

It is obviously our duty to develop methods of increasing food supplies as fast as we can, whether by teaching backward peoples to do better, or by putting capital into great irrigation works, or by the charitable gift of the excesses produced in some parts of the world to the places which are short. There is also the possibility of new sources of food—cultivating the oceans or synthesizing food from chemical elements—but we have a long way to go to develop these on any effective scale. A lot of other things will be running short in addition to food, but food will be the central problem for mankind in the future.

If we go on as we have, the population will be 5 billion in 50 years, 10 billion in 100 years, 20 billion in 150 years. The world must some day revert to the old condition in which its population stays, roughly speaking, constant. We may expect this to happen within a couple of centuries, or even more probably within a century. It is likely to be so near that some people now living may well see the beginning of this change back to the condition of constant populations.

TOO MANY MOUTHS

Perhaps we have put the problem of food supply the wrong way 'round. We are told the number of people there are going to be, and then we have set ourselves the duty of seeing how to find the food for them. The right way to take the matter may instead be to examine how much food we can possibly produce, because we can be certain that there will always be too many mouths asking for it. This is, after all, the present condition, it has been the condition all through the past, and it accords with man's fundamental nature as an animal.

LAW OF INCREASE

One of the fundamental laws of animal life is so obvious that it is taken for granted and it has not even been given a technical name. Let us call it the Law of Increase—the tendency of any animal population to multiply in numbers as far as it can. When a ship is wrecked on an uninhabited island the rats get ashore and, finding no rival population, proceed to multiply until the limit is reached and there is no further food for them. Any animal that does not have this tendency to increase will always be beaten in the struggle for life by those which have it.

Now man most certainly obeys the Law of Increase, and he is illustrating this most impressively at the present time. Indeed it seems that we are just now behaving like the rats. If we want to avoid famine, pestilence or massacre, as we most certainly do, we have got to solve one of the most tremendous of problems, how to break one of the fundamental laws of nature, the Law of Increase.

ONLY MAN

The prospect of breaking a law of nature which our ancestors have obeyed for a billion years is formidable enough, especially when we have only about a century to do it in. There would seem no reasonable hope of doing it but for one consideration: man has already discovered how to get around another law, the Law of the Non-Inheritance of Acquired Characters.

Loosely speaking, it signifies that an animal derives all its future qualities from the germ through which its parents started its life, but carries no record of any character *acquired* by the parents during their lives. Like the animals, we obey it completely, but we have discovered how to get around its consequences, by education and intercommunication, to a degree that is forbidden to all other animals. We have succeeded several times to our great advantage: first by inventing tools and the use of fire, then by agriculture, then by city life, and now by our control of the world through understanding the laws of nature.

It is because of this success in getting around one law of nature that we may possibly succeed again. There are two most formidable difficulties, one scientific, the other political.

WEEDING

The scientific difficulty is with genetics. Inheritance is in many ways wonderfully accurate, but it is not perfect, since each of us has a few mutations which are probably more likely to produce harmful than good effects. In wild animals this does not matter. Indeed this is one of the essential conditions which make the laws of genetics work—the very severe weeding out of most of the mutations by killing off those who carry them.

Can we devise a substitute? By keeping a complete genetic record for each of us and requiring an expert to determine if there are likely to be too many bad mutations for a prospective marriage, it is imaginable that we might. Although we don't yet know enough about genetics for anything like this, we may soon.

RESEARCH
OF DEPTH AND IMAGINATION

Working in the favorable atmosphere of pure research and practical application, Firmenich has made imaginative and substantial contributions to the field of flavor. By isolation, identification and synthetization, precise and potent flavors, possessing all the desirable organoleptic qualities of the originals, have been achieved. By new and exclusive techniques, these materials are now also available in powder form to give further application in flavoring. The depth of Firmenich research is evidenced in the award of the Nobel Prize and four medals administered by the American Chemical Society. The originality of Firmenich research has been shared with fellow scientists in more than 300 technical papers. Firmenich technicians are highly qualified to assist you in the use of Firmenich flavors in developing new products, in giving fresh appeal to those long established.

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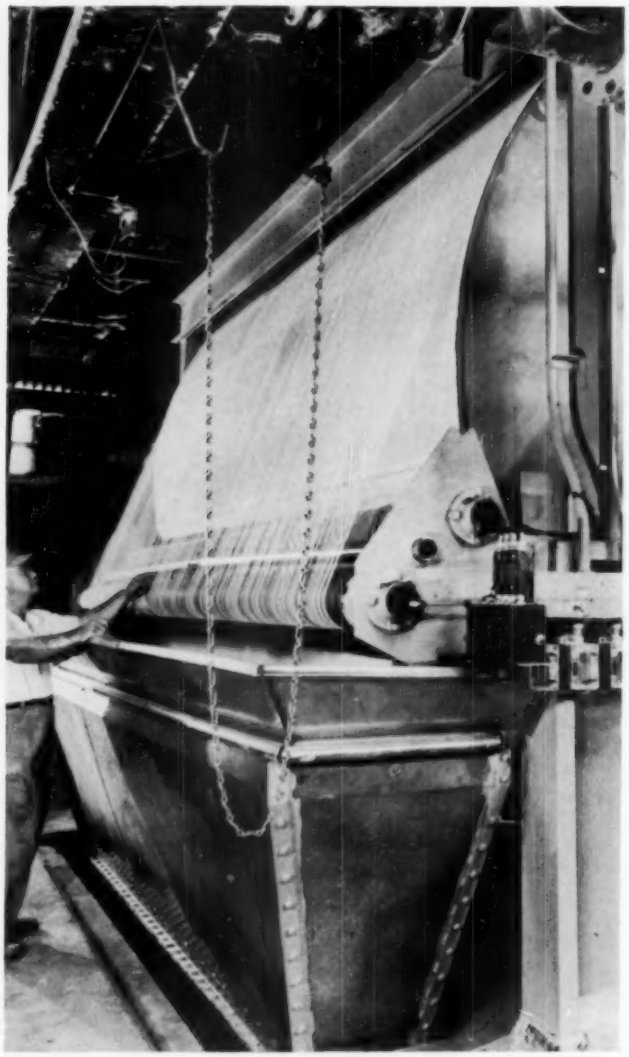
LOEBEL

BELOW: One of the two Oliver String Discharge Filters used for starch dewatering at A. E. Staley Mfg. Co.



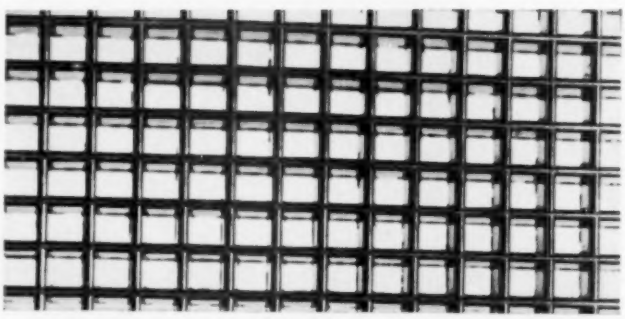
Dorr-Oliver advanced design filtration equipment gives A.E. Staley Mfg. Co.

HIGH CAPACITY STARCH PROCESSING

Modernization of starch processing at A. E. Staley Mfg. Co., Decatur, Ill., includes high capacity dewatering prior to drying provided by two Oliver String Discharge Type Filters.

These stainless steel filters are typical examples of the flexibility offered by Dorr-Oliver equipment in meeting specific job requirements. Special features include the new D-O molded rubber sectional waffle-type drainage deck. This design provides the greatest amount of open drainage area available in any type of grid, resulting in high filtering capacity and exceptionally low filter cake moistures. The smooth, rounded rib surfaces offer excellent support for the filter media, increases cover life and provides for easier cleaning without removing grids. The special rubber composition eliminates the problem of corrosion at a most vulnerable point.

For more information on the complete line of D-O equipment for the starch industry, write Dorr-Oliver Incorporated, Stamford, Connecticut.



ABOVE: New waffle-type rubber drainage grid installed on the above filters. Approximately ½" square openings provide exceptionally large drainage areas. A sample of this grid will be sent on request.

DORR-OLIVER

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

But in 50 years we would need 5 billion marked cards and 1 million geneticists to fill them out. Would the average man be willing to obey orders given in such an abstruse way on a subject he didn't understand? The most likely answer is that he would not. If we are to avoid the extremes of the struggle for life, then, we shall have to pay as the price a steady, slow degeneration in the qualities of the human race.

NICE NUMBERS

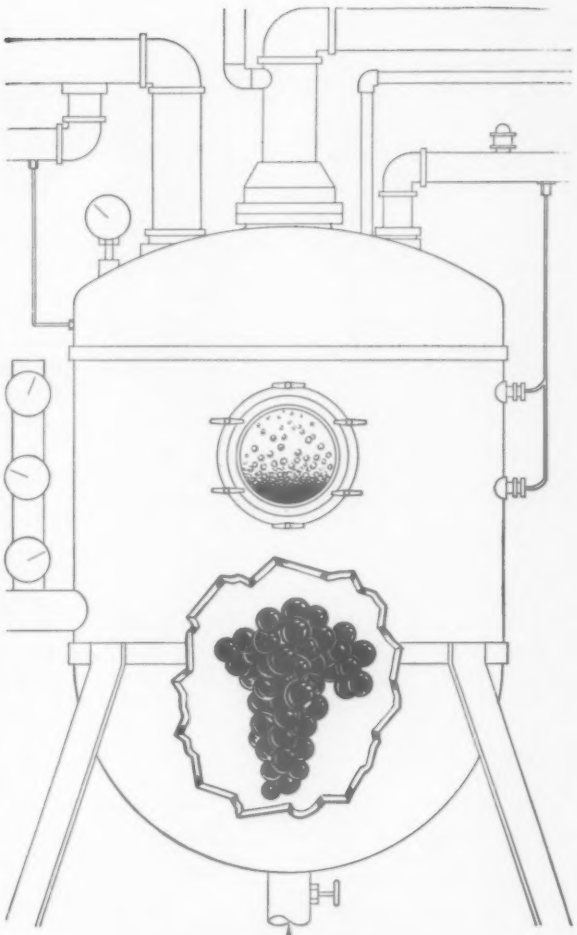
The political difficulty—even more formidable—is due to instability. Suppose we have a satisfactory and humane method of limiting our numbers. There must then be a set of rules to decide what those numbers had best be. Who is going to settle those rules? Suppose half the world decided that we are very nice as we are now and holds its numbers constant, but the other half does not agree, because it likes a crowded world, has religious principles forbidding limitation, or is plainly negligent. Whatever the reason the numbers of the two groups, once equal, will, 50 years later, be as two to one, and in a century four to one. In the long run the mere numbers will win, and we shall have failed to keep the population down in the way we intended. This accords with the Law of Increase, and shows how deep it lies among the laws of nature, and how difficult it may be to overcome it to permit the continuation of the prosperous life we are now enjoying.

This is far and away the most important problem facing the human race. It would be nice to see a solution which would permit us to retain prosperity indefinitely, but it is a truism that whatever we can create there will always be too many asking for its benefits. Let us hope that someone may hit on a wholly new idea which will prevent the world from relapsing into the old hard conditions of the severe struggle for life.

Three Elected to Executive Committee

Final ballot count of Executive Committee nominees reveals that Stephen L. Galvin, New York Section, Wallace R. Roy, Florida Section, and Loren B. Sjostrom, Northeast Section, are new members of the Executive Committee of the Council for two-year terms. Other nominees were: William D. Brown, F. S. Erickson, and Hamilton W. Putnam.

Membership of the 1961–62 Executive Committee will consist of the newly elected named above, and Carlos A. Greenleaf, Washington, D. C., John H. Kilbuck, Northern California, Herbert E. Robinson, Chicago, President Schultz, Past-President Hutchings, President-Elect Jackson, and Treasurer Prater.



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The "Multiplier Effect" of Frozen Food Technology on American Life*

THE DISTINGUISHED French physiologist Bernard is alleged to have said: "We stand on the shoulders of those who have gone before us so that we may peer over the wall into distant horizons."

Hence, in accepting the great honor of the Nicholas Appert Award, the speaker acknowledges, on behalf of one of the youngest of the world's food industries —*the frozen foods industry*—our debt of respect and gratitude to those thousands, in research and business, who helped establish the *older* food-processing industries of this country, notably the canning industry, from the technology of which the younger industry has often benefited in its growth through a generation.

And because my own professional activities have been mainly in the field of frozen-food technology, beginning in 1924, I acknowledge my personal indebtedness to my many associates in research, whose devoted interest and cooperation have together helped build this young industrial giant, the products of which are now estimated to approach close to a three-billion-dollar market value, annually.

One cannot name them all or list the research agencies, public and private, that have had a part in this astonishing development. Perhaps, however, mention should be made of one of the most unusual investigations in American food history, which has been so productive in providing advance and parallel technical information to aid the practices of the frozen-foods industry.

I refer to the time-temperature tolerance investigations of the Western Regional Research Laboratory of the U. S. Department of Agriculture. The pages of the Institute's important journal—FOOD TECHNOLOGY—have given good evidence, through several years, of the productivity of the scientists and engineers of that group in almost two dozen major reports discussing the behavior, in relation to temperature and time and the microbiology of the major frozen fruit, vegetable, and poultry items.

Here we begin to observe the "multiplier effect" of the frozen foods industry, to which Dr. M. F. Gunderson, of the Campbell Soup Company, recently referred so aptly. For the pattern of time-temperature studies has now been adopted by scientists in other commodity fields—frozen fisheries products, meat products, bakery products, and candies and military rations. Further, even some food items generally considered non- or semi-perishable have now been subjected to time-temperature studies in order to evaluate more intimately their potential commercial shelf life in various ambient environments.

The "multiplier effect" is a characteristic of some industries, which not only create and build intrinsic industrial developments and employment but also catalyze a great variety of accessory and related industries to utilize their products or to serve their requirements.

Freezing preservation of foods is a very ancient art and has long been employed by primitive and civilized peoples inhabiting regions with very cold climates; the Eskimo practice is the most striking example of this native art.

Full exploitation of this method, however, awaited the development of mechanical refrigeration. Only then could its values be used industrially in other climatic zones. In fact, even after mechanical refrigeration was available, many years passed before its application to commercial food freezing was envisioned.

Perhaps the first reference to such use was made by Fulton, in a USDA circular in 1907. In 1912, H. A. Baker, of Denver, whom many regard as the father of the modern frozen-food industry, first employed freezing to preserve red sour cherries, in the Rocky Mountain region, and several berries, especially strawberries in the Pacific Northwest, in a method then referred to as "cold pack."

When Nicholas Appert applied his pioneering talents to the preservation of foods, at the direction of Emperor Napoleon the First, and so established the first principles of processing foods in metal canisters by heat, he doubtless scarcely imagined that one hundred and fifty years later another great food industry would arise, employing the absence of heat as a preservation method.

When the pioneer researches, over fifty years ago, of Prescott and Underwood—our own beloved Samuel Prescott—created the technical foundation of the National Canners Association and its subsequent valuable researches, the commercial freezing of foods was scarcely in the minds of even the most mentally alert scientists or food packers.

The cold-pack industry of the Pacific Northwest gradually expanded with the courageous vision of such leaders as Ralph Bodle, Bert Maling, Mark Ewald, William MacCaffray, and Edgar Burns, to name but a few. Here and there also, one heard of daring attempts to freeze other items, such as corn on the cob, in the Middle West about 1917, when control of enzymatic action by preliminary steam or water scalding, now considered essential for frozen vegetables, was as yet unknown. Probably the first reference to this was by Edward Kohman, in 1927.

Then another man of vision—an engineer named Clarence Birdseye, who received the Babcock-Hart Award in 1949—sensed the great potential in employing freezing procedures as a means of commercial

*1961 Appert Award Address presented at the Twenty-first Annual meeting of the Institute of Food Technologists, Statler Hilton Hotel, New York City, May 10, 1961, by Dr. H. C. Diehl, Colorado Springs, Colorado.

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food preservation. His enthusiasm stimulated a great food manufacturer of this country, the General Foods Corporation, especially because of the vision and energy of one of its honored leaders, Edwin Gibson, to initiate pioneering research and merchandising activities in the twenties of this century.

If we look back, we can recall the names of scientists who sought out the secrets of this new food preservation method—Cruess, Mrak, Joslyn, Bjarnasson, Wiegand, Fellers, Tressler, Woodroof, Prescott, Tanner, Magoon, and Berry—to name but a few.

These pioneers were followed by a host of other capable investigators, whose devoted efforts ever widened our knowledge and set the stage for the profoundly comprehensive time-temperature tolerance investigations, already mentioned.

In 1931, the Frozen Pack Laboratory of the United States Department of Agriculture was established at the Spokane Street Dock of the Port of Seattle. Thus, this Department, through the Chief of its Bureau of Plant Industry, that grand old man Dr. William A. Taylor, gave concrete recognition to the vast potential, for farmer and industrialist, of this method of food preservation.

Great areas of research in enzymology, microbiology, chemistry, physics, engineering and economies were opened up gradually by the technical problems and needs of the infant indnstry. The prevention or retardation of chemical and microbiological changes in foods was sought at the low end of the temperature scale, which has finally, through the years, centered on zero degrees Fahrenheit.

A whole new field of plant breeding ensued in order to provide raw materials having the special qualities required for maximum success in freezing preservation. Existing harvesting and handling equipment was modified or new devices were invented, designed and engineered to meet the special needs of the farmer who produced crops for freezing. Emphasis on retaining, as nearly as possible, the natural characteristics of foods by the freezing methods gave special impetus to the refrigeration of raw materials in the pre-process handling, which then intensified interest in the canning industry also in such procedures. Thus, the young industry was already repaying its anteceedent—the canning industry—with useful information, as the fresh knowledge of children often stimulates their parents.

Since efficient removal of sensible and latent heat underlies the freezing method, much research effort has been directed toward a more precise understanding of heat transfer, boundary conductance phenomena, dissipation of latent heat, and the character and influence of ice formation on plant and animal tissues, both as a fundamental phenomen, as done presently by the National Research Council of Canada, and in the context of commercial operating practices.

Many devices and types of equipment for freezing foodstuffs, which could qualify for the popular terms

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★ CARE AND CONTROL

"quick freezing" and "deep freezing," were designed, engineered, constructed, and tested for industrial use. To list and discuss these would in itself make a dissertation too long for our present purposes.

Perhaps one individual should be mentioned because of his profound contributions to the knowledge of food freezing—William J. Finnegan of Los Angeles, an inventor and consulting engineer whose penetrating studies revealed many useful facts about boundary conductance and the development of internal pressures in tissues through ice formation. In the refrigeration equipment field, the "multiplier effect" of the frozen foods industry has been strikingly in evidence through the years.

Packaging of frozen products demanded the talents and experience of many investigators and manufacturers. Atmospheric oxygen and tissue catalysts, in vegetable and animal tissues, are capable of causing undesirable oxidation and quality losses, even at freezing temperatures, so product protection came into primary focus. Since the products of a new technology were involved, the "multiplier effect" principle again activated a host of package-design and protective developments in the paperboard, metal and foil container fields, the last of these innovations being the adaptation of aluminum metal to packaging frozen citrus concentrates in a variety of forms.

In the wooden container field, notably wire-bound cases for frozen poultry, and in the flexible package area, relatively air- and moisture-tight enclosures were developed to give more thorough protection to the frozen products.

Constantly, the highly competitive nature of the American food economy and the ever-mounting labor costs of any industrial practice made manufacturers and users of frozen-food packages more cost-conscious —and in recent years, sometimes, unfortunately, less product-protection-conscious.

Search for new packaging materials, to be fabricated and used in convenience formats for the food consumer, as, for instance, the current boil-in-pouch packaging, was markedly stimulated in the paper, plastics, and metal fields. The "multiplier effect" of the frozen-foods industry has been nowhere more apparent than in the packaging industries.

As a result of emphasis on product-protective factors, a new concept in packaging arose—protective microclimatic environment—by taking a leaf from the book of the microclimatogists, which science in the last decade or two had its inspiration in this country through the pioneering work of Thornthwaite at the Laboratory of Climatology in New Jersey.

Our attention has been focussed on the fatigue and failure of paperboard *shipping* cartons due to the unique character of the handling and storage environment surrounding frozen foods. *Shipping* containers for canned foods are substantially supported by their contents, but the different forms of many frozen food packages do not provide this internal structure. Hence, the compression behavior of *shipping* cases at

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American Food Laboratories proudly presents the latest addition to its family of instant liquid stabilizers: an ILS that embodies LECITHIN as a main constituent. After several years of intensive laboratory research and months of continuous on-the-job usage in many of America's largest food processing plants, the valuable properties of LECITHIN are offered to the food processing industry in the form of an instant stabilizer that blends immediately with any hot or cold mix, disperses instantly and vastly improves texture, smoothness and flavor.

LECITHIN has long been known as nature's principal surface active agent, and has a unique ability to stabilize, disperse, emulsify, wet, spread, and retard oxidation. With the addition of INSTANT LECITHINATED STABILIZER, a fully patented and U. S. Government approved product, perfect emulsions are produced and remain stable even throughout long storage in open display cabinets.

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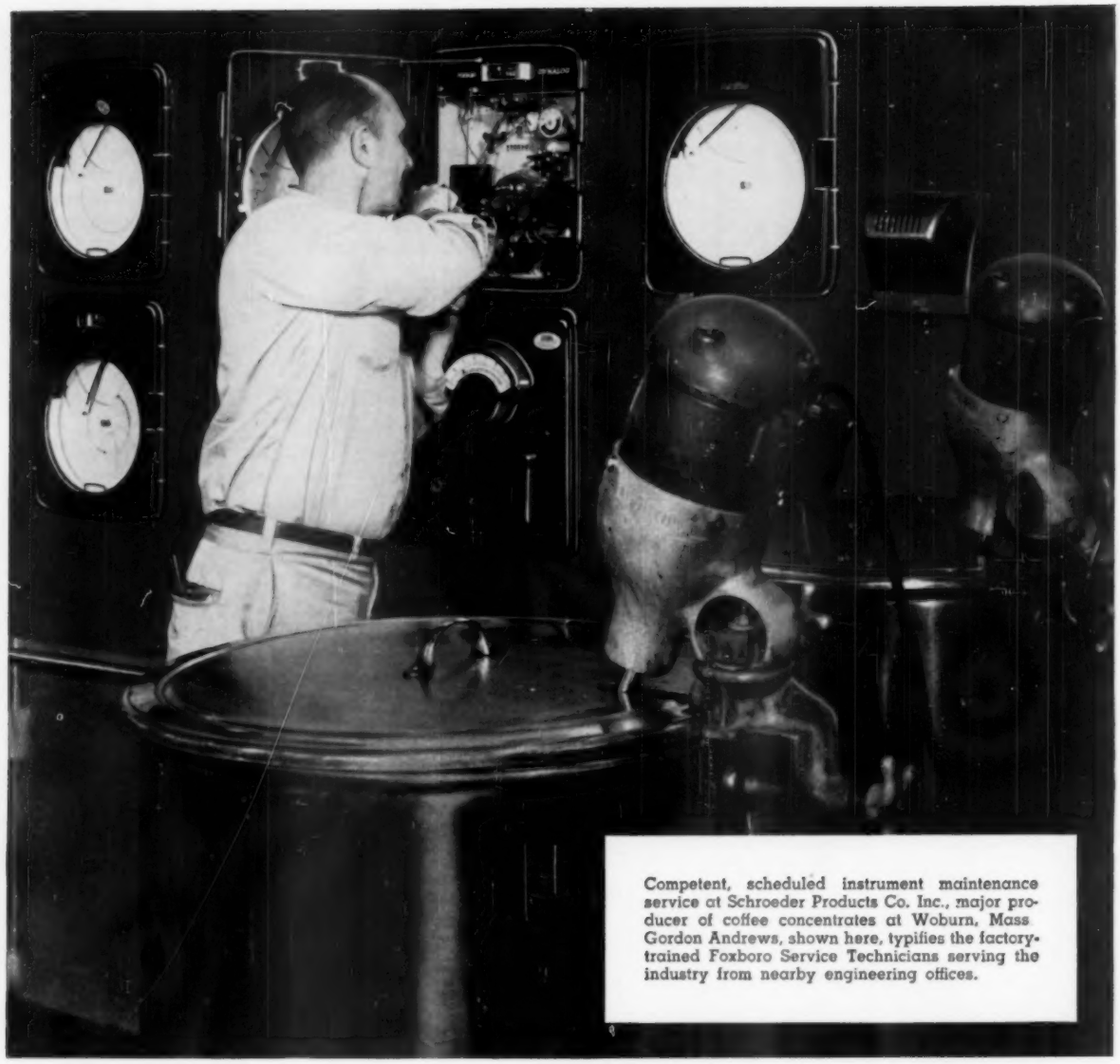

Competent, scheduled instrument maintenance service at Schroeder Products Co. Inc., major producer of coffee concentrates at Woburn, Mass. Gordon Andrews, shown here, typifies the factory-trained Foxboro Service Technicians serving the industry from nearby engineering offices.

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varying ambient temperatures and humidities became of paramount importance, affecting both potential package- and product-damage as well as warehousing and shipping practices.

These problems became even more urgent of solution as refrigerated warehousemen built modern one-story structures designed especially for materials-handling purposes since palletized stacking heights rose to previously unheard-of pinnacles. Waterproofing and bursting-strength specifications assumed greater importance, and the classic Mullen bursting-strength test gave less satisfactory indices of performance under these circumstances.

When we think of packages, we immediately have before us the whole galaxy of frozen-food brands and labels, the design and production of which has occupied the effort of many man- and woman-hours.

Then we turn to the advertising profession, which has given thousands of hours of study, art work, and other production functions so as to place before the public eye, in the typically American way, the attractive and even enticing descriptions of the many frozen products that appeal to the American consumer.

Food editors, extension nutrition and home economics specialists, writers—dozens of persons engaged in these professions—have spent thousands of hours in preparing informational material, and in making it available in live voice, visually and aurally, and in print to the American public to instruct it in the character and usefulness of frozen foods. Research agencies, such as the University of Wisconsin Foundation, have carried on thousands of tests to determine the comparative retention of nutritional properties and the composition of frozen foods.

Publications specifically devoted to frozen foods, such as *Quick Frozen Foods, Frozen Food Age,* and *Frosted Food Field,* to name those currently most prominent, came into being to convey essential technical information about frozen foods to thousands of readers and to inform the trade of significant happenings in the many ramifications of the frozen-foods business.

Obviously, frozen foods, after processing and packaging, must generally be transported to distant markets. As a result, striking developments took place in refrigerator rail cars—longer and larger reefers, unique insulation materials and installations, floor and side racks to expedite refrigerated air flow about the lading, axle-activated fans for this purpose, and, finally, the mechanical refrigerating unit, which is now a "must" for frozen-food long-haul transport.

Somewhat later, but at present, no less vigorously, the motor transport industry has also striven for constant improvement in the design and insulation of refrigerated trailer bodies with specifically engineered mechanical refrigerating units. For instance, the trade associations of trailer manufacturers and motor carriers joined, about 6 years ago, with the United States Department of Agriculture and the National Bureau of Standards in an intensive investigation of trailer body performance both in test labora-

tories and in over-the-road runs. New forms of air-tight and water-resistant insulation and desirable trailer-body modifications have been demonstrated and implemented. A truck-trailer rating procedure is now available to provide information as to the basic U value of the body and the refrigerating capacity of the mechanical unit.

Local-delivery motor hauling has also come under intensive scrutiny because the repeated opening of truck doors for multiple deliveries during the day poses a difficult problem of maintaining adequate frozen-product temperatures.

In all this intensive industrial effort, we are always aware that successive rises in frozen food temperatures add additional cumulative and irreversible quality loss, in relation to time and temperature magnitude. Truly, frozen foods have a memory for abuse.

Hence, investigations in local delivery have indicated the value of flexible, protective door curtains, compartmentalization of local-delivery truck bodies, and, lately, the rapid reduction of air temperatures in such bodies by the thermostatic valving of liquefied gases, such as nitrogen.

Only the briefest highlight references to these research and industrial developments are possible here with repeated emphasis on the "multiplier effect" of the youthful frozen-foods industry on a great variety of other industries and areas of industrial action to meet the specific needs of this young giant among food industries.

The dollar investment in new industrial manufacturing actions and consequent employment, catalyzed by the frozen-foods industry in three decades, as well as the value of special services required, mounts into the billions of dollars.

Refrigerated warehouses, public and private, have been designed or modified specifically for freezer storage, lately with refrigerated loading docks so as to minimize product temperature changes during the necessary accumulation and transfer of frozen foods. To expedite adequately protective handling and to reduce labor costs, containerization and pallet unitization of frozen foods is now under very active study, and these practices are likely to be widely adopted in the near future.

And the latest and most modern procedure for the so-called frozen-food break-up operation of a major food chain, in zero-refrigerated space, provided by a public warehouse in Chicago, is a completely automated installation. And a similar operation, partially automated, is now operating in the metropolitan New York area, in Secaucus, New Jersey.

Frozen foods must be retail-merchandised, of course, if one excepts for the moment the large institutional use of these products. Extensive investigation and implementation of design and performance improvements have been given by engineers and manufacturers to creation of the retail freezer cabinets, which have, until now, been of the horizontal display type.

There have been some inherent disadvantages in this type of display case, even though conscientious effort has been made to minimize these. Now, for merchandising and protective reasons, much attention is being given to upright, self-service cabinets, a few of them of the type commonly called air-curtain cabinets. The most striking of these, soon to be tested in large food chain stores, employs the dual jet principle to provide positive low-temperature protection uninfluenced by ambient store atmospheric conditions.

The "multiplier effect" of the frozen-food industry is manifest again and again in all these enterprises.

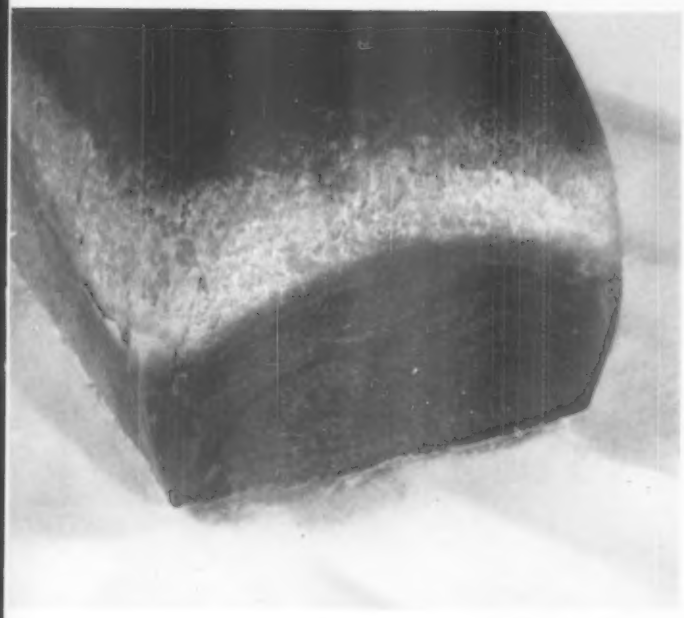
Not only in the manufacture of freezer cabinets for retailing and retail backroom storage but also in the production of home freezer cabinets has this effect of frozen-foods technology been evident. Hundreds of thousands of freezer cabinets and freezer-compartment domestic refrigerators, of many designs, have been acquired by the consumer and are in constant daily use for what is hedonistically called "better living in the American way." And these home freezers, during World War II, provided a way of conserving home-grown produce, meat, poultry, and even bread stuffs.

Catalyzed by freezing technology, an entirely new industry sprang up in the last several decades—the freezer locker industry, which supplied as well as supplemented home-freezer capacities. During World War II, the facilities of more than 10,000 locker plants were important factors in food conservation. As time passed, this industry offered other food purchase and preservation services, especially in rural and suburban areas, and has there especially justified its historic function as a service to the American people.

In the Armed Services, especially air-force and submarine, where variety and appetite appeal of foods are important for the efficiency and morale of personnel, frozen foods have served admirably. During World War II, the introduction of frozen foods for use in camps and forts on the mainland, of which the speaker has intimate knowledge, released heat-processed and dehydrated foods for use in distant battle areas and helped to release strategic metals such as steel and tin for other important uses.

The "multiplier effect" of the frozen-foods industry has had its influence also on the economies of farming. Many agricultural areas that had previously marketed most of their produce in unprocessed form could now add to their production that which the economist calls "manufactured value," which includes both employment of labor in those areas as well as longer shelf life and more consistent and remunerative returns to the producer of raw materials. Any successful food-processing method does this; the canning procedure has had that influence for years.

An example is the white potato industry. Contemplate the beneficial "multiplier effect" of freezing technology in extending the market for potato growers, in such items as frozen French fries, which now rank at the top of frozen-vegetable categories.



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THE PROBLEM: *Develop a superior emulsified shortening to meet the needs of today's wholesale bakeries.* As more and more large scale bakeries turn to automated production facilities, ingredient suppliers must adapt or develop products expressly for the bulk handling systems such facilities require. Durkee, long a supplier of emulsified shortenings to the bakery industry, turned to its Technical Service Staff to meet this challenge.

THE SOLUTION: *Liquefy, Emulsify, Infuse:* Producing emulsifiers for over 20 years, Durkee knew what potential baking improvements lay waiting the development of a workable combination of emulsifiers and oil in one pourable, pumpable fluid product . . . a product built for automated bulk handling systems. Using developmental and production procedures learned through those years of experience, Durkee perfected a method of infusing microscopic crystals of a unique emulsifier into a top quality liquid oil that produces lighter, finer textured baked goods with longer shelf life. We named this new shortening FLUID FLEX.

THE SIGNIFICANCE: *Revolutionary.* Here again, Durkee's technical competence in the fields of fats and oils led to an entirely new concept of production for an entire industry *before* the industry knew it could be done. Purposeful research is continually in progress at Durkee. Here is where we may be able to help you most whenever your product or process warrants further attention. We'd be glad to help. Just phone or write.

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In fact, the vast prepared or convenience frozen-food extension to a multiplicity of items, not only conventional but also of exotic and gourmet character, has offered a variety of choice, undreamed-of in many parts of the world, to the American consumer, whose current economic status permits him to have a wide selection of nutritious foods.

Now recently, the boil-in-pouch convenience foods, available presently primarily for institutional use, such as the unique Continental Cuisine of the Armour group, has opened new vistas in restaurant operation and hospital use. This cuisine offers a menu variety that presently can be provided only by certain restaurants at considerable cost. With such prepared items, the preparation-labor cost and equipment requirements in food-serving establishments can be remarkably reduced, and instantaneous preparation upon order is possible, with such foods possessing most desirable appetite-appeal and nutritional qualities.

Convenience frozen foods even have sociological influences on American life—whether for better or worse is not germane—since items such as TV dinners have sometimes moved family meals from the dining table to individual portable trays, so that those who nourish themselves gastronomically can do so without missing that visual and audio stimulus over the air-waves that so many Americans consider essential to contented living.

One of the unique "multiplier effects" of freezing technology can be observed in the present marketing of sea foods, compared with a few decades ago. Prior to the development of processed and packaged frozen sea foods in retail trade, the freezing of whole fish, often for sale in defrosted form, had been the limits of this technology in the fisheries industry. The extent to which fisheries products could be marketed was limited, in time and in distance, relatively close to oceanic or lacustrine shores.

But now frozen sea foods in great variety and in convenience form are available far and wide in the land. The consumption of fisheries products in a country not really regarded as sea-foods-minded, the United States, is increasing substantially, with consequent nutritional benefits for the American people.

Consider, in the "multiplier effect" relationship, the influence of freezing technology on the baking industry. But a few examples of this effect are such important economic factors as more efficient production and delivery scheduling, savings in labor costs, and elimination of the problem of disposing of the so-called stales. The bakery-products industries stand before a revolutionary change in production and marketing procedures in the next decade because of freezing technology.

Or, give a moment's thought to the "multiplier influence" on the marketing of citrus fruits, especially oranges, when the technique of freezing citrus juice concentrates became widely adopted. And consider the massive impact of this industrial development on the supplier and service industries, involved in

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making it possible for the consumer to obtain these citrus juices. And, in seeking the highest product quality, a multitude of research and control problems connected therewith, occupied the time and talents of many investigators, engineers and production managers.

Certainly, the initial achievements of freezing technology aroused interest in two other related processes —dehydro-freezing and freeze-drying. The former already possesses commercially demonstrated usefulness, at least at present, as an intermediate process in food manufacture. The latter—freeze-drying—presently attracts widespread commercial interest, because of the unique properties of its products.

It is possible that we will find that even freeze-dried products will be benefited by storing under refrigeration—even as a frozen product—especially if it is deemed desirable not to extend the freeze-dehydration process to the present product moisture content, for economic or technological reasons.

So the extent of this potential horizon is not completely discerned at the moment.

Some enthusiasts have claimed in recent years that the era of refrigeration for foods is coming to an end. The progress and unexploited potential of freezing technologies hardly justifies such unqualified predictions.

If the speaker's theme of the "multiplier effect" of freezing technology has had any point for his audience, these random—and by no means complete—examples of this phenomenon will suffice.

The benefits to American industry, as a whole, of a new industry with a "multiplier effect" are profound and far-reaching. Would that we could create many such "multiplier" enterprises!

The few minutes that we have spent together considering this matter have stimulated, it is hoped, our interest in the frozen-foods industry, which still has a great unexploited technical and industrial potential. Such industries not only have an intrinsic place in the American economy but also are catalytic factors in stimulating new research, inventive manufacturing, merchandising and utitlization enterprises in many directions, thus ultimately employing the talents and energies of thousands of persons. Such people, if they were adults a generation ago, had not *then* the *slightest* idea that such an industry as frozen foods would offer constructive professional labor and business opportunities for them and their descendants.

The speaker expresses again his gratitude for the high honor of the Appert Award of the Institute, and accepts it as a tribute more properly to his many associates in frozen foods research and business—the many individuals whose vision and devoted efforts have made possible, in about a generation, the creation of an astounding American food preservation industry that has spread its influence abroad to foreign lands.

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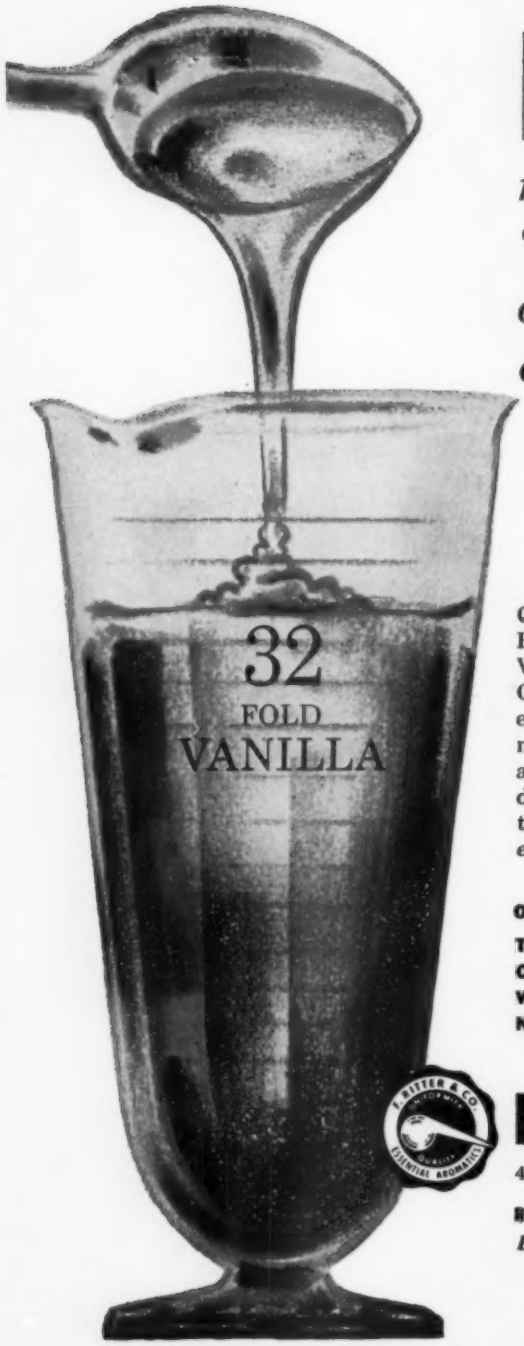

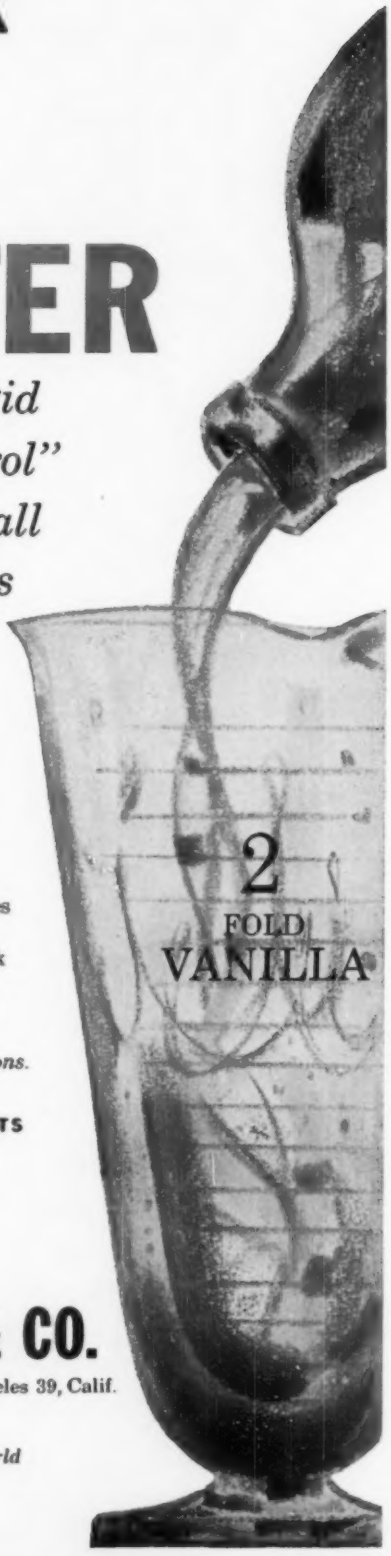

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Studies on Frozen Fish. II.

Some Chemical Changes Occurring During Frozen Storage

(Manuscript received January 3, 1961)

P. L. Sawant and N. G. Magar
Department of Biochemistry, Institute of Science, Bombay, India

SUMMARY

The effect of frozen storage and glazes on some chemical changes in fish was studied. Moisture content decreased on storage, whereas total protein nitrogen apparently increased. Total amino-nitrogen decreased. The loss in total amino acids and change in PDR index of fish was observed during frozen storage. The changes mentioned above were slowed by glazes. The ratio of Ba-acetate nonprecipitable ribose to total ribose increased during storage. The possible route of formation of Ba-acetate nonprecipitable ribose has been suggested.

THE EXTENT of denaturation of proteins during frozen storage of fish has been studied by many workers. No data are available, however, on other chemical changes during frozen storage. An attempt is made here to study the effect of frozen storage and of different glazes on per cent weight loss, moisture, total protein, amino-nitrogen, and amino acids contents, on the net utilization of proteins (PDR index), and on the ratio of Ba-acetate nonprecipitable ribose to total ribose.

MATERIALS AND METHODS

The conditions of freezing and frozen storage, and the materials used, have been described (Sawant and Magar, 1961). The frozen fish was thawed for 4–5 hr at room temperature after taking weights. Considerable "drip" exuded during thawing. Total protein nitrogen and amino-nitrogen were respectively estimated by the methods of Kjeldahl (A.O.A.C. 1950) and Spies and Chamber (1951). Microbiological procedures were used for the determination of essential amino acids (Sawant and Magar, 1958). Net utilization of proteins of frozen fish stored for four months was determined by the method of Sheffner *et al.* (1956a), using egg albumin as a standard protein, by calculating the geometric mean and by applying the correction factor as suggested. Ribose was estimated from trichloroacetic acid (TCA) extract by Mejbaum's method (1939) and also after precipitating with barium acetate in 80% ethanol (pH 8.2). The ratio of barium acetate nonprecipitable ribose to total ribose is denoted as "R."

RESULTS

Table 1 shows % weight loss, moisture, total proteins, amino-nitrogen contents, Ba-acetate nonprecipitable ribose, total ribose, and R values.

Pomphrets. The weight loss of pomphrets in the control group, 6% in 1 month, gradually increased to 17% at 9 months of storage. Weight loss was less in glazed fish and fish kept in gunny sack. Ascorbic acid dip given to fish prior to freezing had less effect. Moisture content decreased rather rapidly in the control group, from 75% initially to 66% at three months and 62% at nine months. Moisture loss was less in other groups. Total proteins increased, with consequent loss of moisture. Total amino nitrogen gradually decreased during storage.

Surmai. Weight loss in the surmai control group was 2% in one month, and 6% in four months. Also noted during storage were loss in moisture content, increase in total nitrogen, and decrease in total amino nitrogen. Such changes were retarded, however, in groups glazed with citric acid, sodium nitrite, and ascorbic acid solution. The ratio R increased from an initial value of 1.5 to nearly 11 in four months of storage.

Mackerel. Moisture content decreased gradually from an initial value of 78% to 72% and 74% in control and blocked mackerels, respectively. Total protein nitrogen increased and total amino nitrogen decreased. R increased from 1.4 to 20 in four months.

Total essential amino acids. Amino acids content of fresh pomphrets, mackerels, and surmai are reported in Table 2; retention after several months of storage is shown in Figs. 1, 2, and 3. The pattern of loss in each amino acid was more or less similar after a regular interval of storage. Retention of amino acids was greater in the glazed pomphrets, surmai, and blocked mackerels than in their respective controls.

PDR index. The amino acids released during 24 hours of Pepsin digestion are shown in Tables 3 and 4. No difference in amino acids released during pepsin digestion was found between fresh surmai, frozen stored surmai, or surmai glazed with different solutions. The trend was similar with fresh, frozen, and blocked mackerel. However, a marked difference was noted in the residue fractions.

PDR indices for fresh surmai and mackerel were 81.9 and 73.5, whereas for surmai those obtained for control, ascorbic acid glaze, citric acid glaze, and sodium nitrite glaze were respectively 49.4, 52.8, 66.4, and 57.3. PDR indices for frozen stored mackerel and blocked mackerel were respectively 49.2 and 58.9.

DISCUSSION

Difference in RH values (about 10–15%) between the surrounding atmosphere and frozen fish resulted in desiccation of the fish. This caused loss in weight of the fish during frozen storage. When the fish is frozen, water is withdrawn from the tissue to form large masses of ice between the fibers, which are thereby distorted and pushed into clumps. When such greatly disorganized tissue is thawed, much liquid

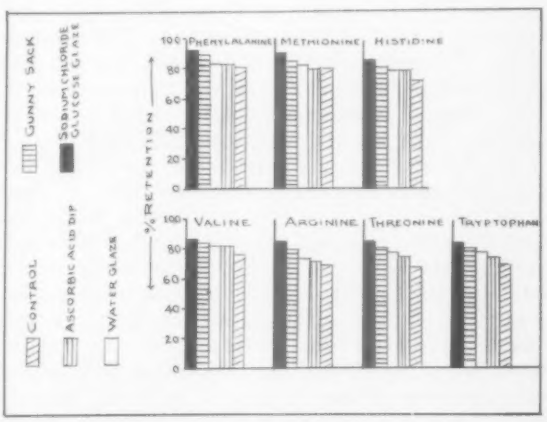


Fig. 1. Per cent retention of amino acids of frozen pomphrets stored five months.

Table 1. Changes during storage in frozen fish.

Preservative[a] and storage period[b]	% wt. loss	Moisture (g %)	Protein (N × 6.25) (g %)	Amino nitrogen (g %)	Total ribose (R_2) (mg %)	Ba-acetate nonprecipitable ribose (R_1) (mg %)	$R = \frac{R_1}{R_2} \times 100$
Pomphrets							
Fresh	.....	75.24	20.51	2.52			
C-1	6.14	71.69	22.08	2.22			
WG-1	3.75	74.67	21.66	2.32			
NaCl-1	2.34	75.50	20.46	2.44			
GS-1	2.66	74.23	20.67	2.40			
AA-1	4.51	75.81	21.06	2.32			
C-3	7.81	66.21	26.51	2.00			
WG-3	5.43	72.85	22.53	2.28			
NaCl-3	3.60	75.01	21.11	2.36			
GS-3	3.99	73.61	22.38	2.30			
AA-3	7.64	71.67	22.62	2.19			
C-5	10.37	63.17	30.16	1.99			
WG-5	8.53	70.06	24.23	2.14			
NaCl-5	6.00	73.38	22.06	2.31			
GS-5	6.92	71.39	23.69	2.26			
AA-5	10.10	68.34	26.39	2.03			
C-7	13.07	62.29	32.03	1.73			
WG-7	11.13	69.43	24.98	1.96			
NaCl-7	8.93	72.96	24.89	2.19			
GS-7	9.71	69.47	24.28	2.13			
AA-7	12.27	66.29	27.18	1.98			
C-9	16.55	61.85	33.61	1.58			
WG-9	13.07	68.85	25.17	1.85			
NaCl-9	10.65	70.84	23.93	2.03			
GS-9	11.65	67.86	27.44	2.01			
AA-9	14.90	64.83	29.48	1.87			
Surmai							
Fresh	.....	76.81	14.93	1.52	99.78	1.53	1.53
C-1	2.36	73.07	16.21	1.11	97.26	2.32	2.39
AA-1	2.00	73.89	16.63	1.25	97.34	2.27	2.33
CA-1	0.82	75.83	15.07	1.34	96.26	2.34	2.43
$NaNO_2$-1	1.26	75.09	15.18	1.30	96.59	2.40	2.48
C-2	4.62	71.79	17.08	0.96	92.34	4.77	5.16
AA-2	2.71	72.61	16.98	1.12	93.82	4.81	5.13
CA-2	1.34	74.29	16.13	1.30	91.35	4.74	5.19
$NaNO_2$-2	1.66	74.18	15.94	1.24	93.55	5.02	5.36
C-4	6.23	70.85	17.51	0.81	68.82	7.62	11.07
AA-4	4.24	71.08	17.74	1.00	69.56	7.42	10.66
CA-4	2.14	73.05	17.42	1.20	67.16	7.33	10.91
$NaNO_2$-4	2.48	72.89	17.67	1.12	66.03	7.53	11.40
Mackerel							
Fresh		77.74	13.50	1.39	94.08	1.35	1.44
C-1		74.15	15.70	1.00	89.98	3.01	3.55
B1-1		76.50	14.69	1.31	91.79	2.79	3.04
C-2		73.71	16.12	0.83	78.35	7.77	9.92
B1-2		76.03	15.01	1.27	78.04	6.96	8.92
C-3		72.44	17.53	0.70	64.58	13.04	20.18
B1-3		74.36	16.11	0.93	65.30	12.60	19.44

[a] C, control; WG, water glaze; NaCl, sodium chloride glucose glaze; GS, gunny sack; AA, ascorbic acid glaze; CA, citric acid glaze; $NaNO_2$, sodium nitrite glaze; B1, blocked.
[b] Storage period, in months, indicated by numbers.

known as "drip" exudes, presumably because some of the extracellular water is free and escapes from spaces between fibers before it can be reabsorbed by them. Drip is increased in the fish stored for longer periods. Thus the observed loss in moisture content of the fish during storage is due to desiccation and drip, as it was determined after thawing. A consequent increase in total protein nitrogen is natural. Also these two processes bring about other important biochemical changes in the fish. Losses from desiccation were less in glazed fish because moisture was not evaporated from the tissue until the glaze was sublimed. Dyer (Dyer and Morton, 1956; Dyer *et al.*, 1956) found no change in moisture and total protein values during frozen storage. His fillets, however, were coated with moss gel and kept in waxed cartons, which prevented loss of moisture by evaporation.

The loss of amino-nitrogen and total ribose does not seem to be due to any carbonylamine type of reaction, since such reaction does not take place at the storage temperature of frozen fish. It is likely that these com-

Table 2. Amino acids[a] content of fresh pomphrets, surmai, and mackerel.

Amino acids	Pomphret	Surmai	Mackerel
Methionine	2.78	3.07	2.99
Phenylalanine	3.07	3.01	3.42
Lysine		5.14	7.12
Histidine	1.83	2.81	2.12
Leucine		7.52	7.31
Isoleucine		4.86	4.51
Valine	5.14	4.68	4.81
Arginine	7.65	7.58	5.25
Threonine	4.53	4.71	4.44
Tryptophan	0.58	1.34	1.15

[a] Expressed on 16% N basis.

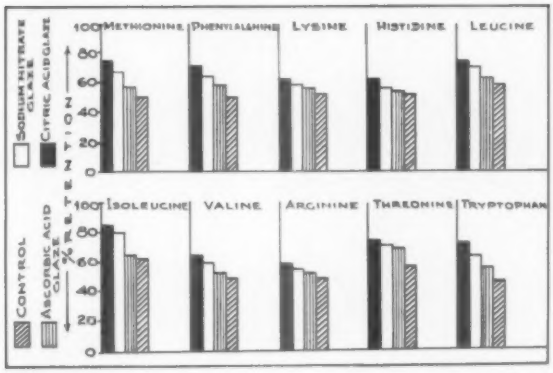
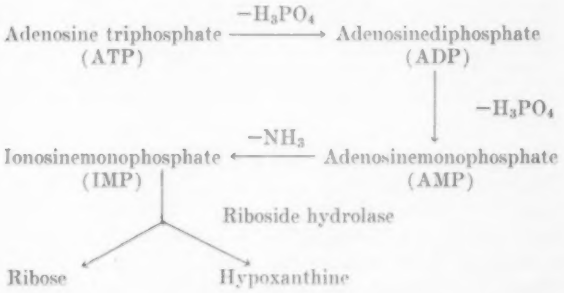


Fig. 2. Per cent retention of amino acids of frozen surmai stored four months.

ponents might be leached out in drip during the thawing of fish.

The pathways concerning the formation of ribose during post-mortem changes of fish muscle have been a subject of considerable discussion (Tarr, 1958). Shewan and Jones (1957) considered the possibility of accumulation of ribose via ionosinetriphosphate (ITP) as the intermediate. Recently Tomlinson and Creelman (1960a) showed ribomononucleotide was the source of free ribose in the lingcod muscle post-mortem. Adenosine or adenine was not detected in these studies; however, ionosine was always present in large amounts (1960b). In our experiments consistent increase in the ratio R during frozen storage indicates the decrease in Ba-acetate precipitable (in 80% ethanol at pH 8.2) phosphorylated compounds with consequent slow increase in Ba-acetate nonprecipitable ribose. From these considerations, the following scheme has been suggested for the accumulation of ribose in frozen fish.



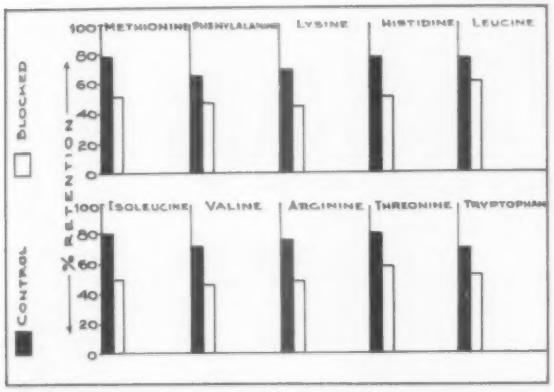


Fig 3. Per cent retention of amino acids of frozen mackerel stored four months.

The presence of protein components in the exuded drip was shown in chemical and electrophoretic analyses by Seagran (1958, 1959). It was therefore likely that the observed loss in total amino acids may be due to the presence of proteins in the drip. The loss in total amino acids was shown by Pearson *et al.* (1959) during thawing of freshly frozen pork. The magnitude of loss of each amino acid was somewhat constant in each group. Pearson *et al.* suggested that the denaturation of proteins that takes place during freezing of pork may cause the same proportion of amino acids to be leached out in the drip. This seemed to be probable since losses in total amino acids were inhibited in glazed fish, where denaturation is less (Sawant and Magar, 1961).

Reported values for PDR index for proteins of animal origin are between 76 and 83 (Sheffner *et al.*, 1956b, 1957). The values obtained for surmai and mackerel are quite comparable. It was shown that denaturation of proteins of fish during frozen storage was not related in any way to the liberation of -SH groups of the proteins (Husaini and Alm, 1955; Seagram, 1956). Therefore, the formation of enzyme-resistant –S–S cross linkages was rare during frozen storage of fish. This would explain why no difference

Table 3. Amino acids content of fresh and frozen surmai.

	Fresh		Frozen [c]							
			Control		Ascorbic acid		Citric acid		Sodium nitrite	
Amino acids [a]	Pepsin digest [b]	Residue	Pepsin digest [b]	Residue	Pepsin digest [b]	Residue	Pepsin digest [b]	Residue	Pepsin digest [b]	Residue
Lysine	1.27	60.97	1.21	35.46	1.18	36.45	1.22	38.83	1.20	36.80
Methionine	2.38	34.79	2.40	19.79	2.41	20.37	2.39	26.79	2.39	23.84
Phenylalanine	6.32	33.72	6.32	14.97	6.26	16.73	6.29	21.12	6.28	18.55
Histidine	0.23	33.83	0.21	16.64	0.22	19.89	0.22	22.32	0.22	20.18
Leucine	21.05	70.05	20.65	26.58	20.54	28.26	20.61	38.20	20.58	35.05
Isoleucine	13.57	45.05	13.26	29.21	13.29	38.11	13.34	47.92	13.47	41.11
Valine	3.84	52.88	3.82	25.50	3.82	25.53	3.84	34.35	3.83	29.34
Arginine	6.80	85.05	6.56	42.98	6.72	44.77	6.68	49.32	6.67	45.68
Threonine	10.81	46.22	10.22	27.38	10.16	32.91	10.43	34.02	10.18	32.65
Tryptophan	5.40	10.84	5.29	3.45	5.34	4.30	5.38	6.93	5.36	5.32
Total	71.67	473.39	69.94	241.96	69.94	367.32	70.40	319.80	70.18	288.52

[a] Expressed as mg/g of protein. [b] Corrected for enzyme blank. [c] Stored for four months.

Table 4. Amino acids content of fresh and frozen mackerel and egg albumin.

Amino acids[a]	Egg albumin		Fresh mackerel		Frozen mackerel[c]			
					Control		Blocked	
	Pepsin digest[b]	Residue	Pepsin digest[b]	Residue	Pepsin digest[b]	Residue	Pepsin digest[b]	Residue
Lysine	1.60	56.71	1.57	80.03	1.56	45.74	1.60	59.60
Methionine	8.29	41.56	1.95	32.40	1.93	20.87	1.93	26.17
Phenylalanine	12.22	43.64	4.85	34.35	4.84	18.96	4.87	22.33
Histidine	0.66	19.50	0.16	24.10	0.16	15.84	0.16	19.74
Leucine	54.79	39.28	17.78	66.04	17.44	48.76	17.48	51.32
Isoleucine	27.85	47.95	9.80	41.86	9.79	23.81	9.83	34.37
Valine	9.79	57.66	3.28	51.79	3.28	28.42	3.27	38.93
Arginine	6.50	51.25	3.74	56.42	3.74	33.86	3.73	44.77
Threonine	21.25	24.25	7.86	43.03	7.81	29.89	7.86	35.04
Tryptophan	6.93	8.55	4.70	8.53	4.67	4.03	4.70	5.10
Total	149.88	390.35	55.69	438.55	55.22	269.88	55.43	337.37

[a] Expressed as mg/g of protein. [b] Corrected for enzyme blank. [c] Stored for four months.

was noted in the released amino acids contents of fresh as well as frozen fish during pepsin digestion. However, the difference in PDR indices was due to the loss in total amino acids, which caused a marked difference in the residue fraction. Thus, Sheffner's method, which combines the pepsin digest fraction with the residue fraction, gives a picture of net protein utilization of frozen fish.

Acknowledgments

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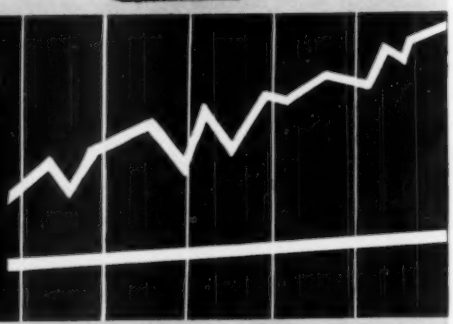

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The Effect of Pure-Culture Inoculation on Fermentation of Cucumbers[a]

(Manuscript received May 2, 1961)

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SUMMARY

A study was made of the effects of inoculating cucumber brines with several species of lactic acid bacteria commonly involved in such fermentations. The course of a fermentation can be controlled by inoculation. The species *Lactobacillus plantarum* completed all fermentations, regardless of original inocula. The lower acid-producing species can effectively dominate the fermentation only to the point of maximum acidity production for those species. Extent of bloating, weight recovery, and visual appearance of the pickles can be correlated with the relative influence of the heterofermentative and homofermentative species. This is reflected in the actual numbers of each type and the total acid, pH, and volatile and nonvolatile acidities. Fermentations in which the heterofermentative species were relatively effective generally yielded a better recovery of solid pickles and improved total weight recovery.

THE RECOVERY of good solid stock pickles from cucumber fermentations varies markedly in commercial practice. The quality of fermented cucumbers may be influenced by the maturity, size, and variety of cucumbers, brine concentrations, holding temperatures, types of fermentation, and other factors. Etchells and Jones (1951) reviewed their 17 years of work on problems of pickle processing. Their summary includes the findings of Jones *et al.* (1941) that yields of bloated stock were drastically reduced when the beginning salt brines were of lower concentrations. Pederson and Albury (1956) demonstrated that the bacterial flora of cucumber fermentation can be influenced markedly by pure-culture inoculation.

This study was initiated to compare the effects of bacterial starters consisting of pure cultures of several species of lactic acid bacteria common to fermenting vegetables. It was developed to include a study of the effects of maturity of cucumbers and the effects of concentration, distribution, and absorption of salt on the quality of pickle stock.

EXPERIMENTAL METHODS

Beginning in 1950, 172 1-gal. jars of cucumbers 1⅝–1⅞ in. in diameter, were packed in a three-year period. Each jar was inoculated with one of five species of lactic-acid-producing bacteria previously found indigenous to cucumber fermentations. Fermentations were initiated in brine containing 138 g of salt, which is 3¾% of the total weight of brine and cucumbers. Jars were held at 18, 25, and 32°C. The course of fermentation was followed by determining changes in total acid and salt, by counting bacteria, by plating and microscopic technics, and by isolating and identifying the organisms involved in the fermentation. In 1951, for example, 3,500 strains prevalent in fermentations were identified. In many cases, the volatile, nonvolatile, and total acids were determined in the completely fermented brines in order to evaluate the effectiveness of the inoculation.

Beginning in 1952, 48 barrels of larger-sized cucumbers were packed in 11 series in a four-year period. Each barrel was inoculated with one of three species of lactic acid bacteria. These barrels were filled with salt brines calculated to be 3¾% of the total weight of cucumbers and water. They were fermented outdoors. The course of these fermentations was followed in part by the methods described above. When the various series were about 6 months old, they were examined by personnel at the L. C. Forman & Sons factory. They were weighed, refreshed, and then graded by an experienced grader with this company. They were classified as good solid stock, cutting stock, and relish stock. Cutting stock included pickles with a slight separation of locules; relish stock was more seriously bloated. Further details of packing and sampling have been given (Pederson and Albury, 1956).

RESULTS AND DISCUSSION

The results emphasized the effectiveness of inoculation in controlling the course of fermentation and curing of cucumbers. This statement should not be construed to imply, however, that inoculation is practical on a commercial basis.

Inoculation with the highest acid producer, the homofermenter *Lactobacillus plantarum*, resulted in exclusive control of fermentation by this species (Table 1). Inoculation with the lower acid-producing homofermenter *Pediococcus cerevisiae* resulted in initial control of fermentation by this species, succeeded and completed by *Lactobacillus plantarum*. Similarly, inoculation with the heterofermenter *Lactobacillus brevis* resulted in fermentation initiated by this species and completed by *Lactobacillus plantarum*. Use of the species *L. brevis* resulted in less constant results than inoculations with other bacterial species. This inoculum developed rapidly in some cases and barely grew in others. When cultures of the low acid-producing heterofermenter *Leuconostoc mesenteroides* was used, all three of the higher acid-producing species developed after this species had produced its maximum acidity. In a similar manner, *Streptococcus faecalis* was succeeded by all four of the other species. The results in Table 1 indicate that the species *Streptococcus faecalis* and *Pediococcus cerevisiae* are less likely to develop in a fermentation. *Lactobacillus plantarum* always appears to be the dominant species at the completion of fermentation.

Extent of bloating, weight recovery of stock, and visual appearance may be correlated with the relative influence of the various homofermentative and heterofermentative species, as shown by actual numbers of each, and the total acid, pH, and rate of volatile to

[a] Approved for publication by the Director of the New York State Agricultural Experiment Station as Journal Paper No. 1261.

Table 1. Effectiveness of inoculum as shown by identity of cultures isolated.

Lot no.	Species used as inoculum	Temperature of fermentation (°C)	Number of cultures identified, 1950, 1951									
			Streptococcus faecalis		*Leuconostoc mesenteroides*		*Lactobacillus brevis*		*Pediococcus cerevisiae*		*Lactobacillus plantarum*	
			'50	'51	'50	'51	'50	'51	'50	'51	'50	'51
G	*Streptococcus*	18	53	51	2	37	33	18	2	1	49	63
A	*faecalis*	25	47	65	35	16	0	30	0	0	112	23
M		32	28	88	10	28	4	94	0	0	130	38
H	*Leuconostoc*	18	1	0	43	98	23	49	11	1	80	45
B	*mesenteroides*	25	0	0	49	31	32	7	36	0	48	153
N		32	0	0	41	34	9	17	0	0	105	139
J	*Lactobacillus*	18	0	0	0	0	82	122	0	0	77	44
C	*brevis*	25	1	0	0	0	64	144	0	2	129	62
O		32	0	0	0	0	63	95	0	1	99	60
K	*Pediococcus*	18	3	0	7	0	11	16	85	63	37	42
D	*cerevisiae*	25	0	1	0	0	0	2	115	124	79	59
P		32	0	2	0	0	1	2	45	91	120	96
L	*Lactobacillus*	18	1	0	0	18	0	0	0	0	147	69
E	*plantarum*	25	0	0	0	0	0	0	0	0	97	166
R		32	1	0	0	0	1	2	0	0	161	175

nonvolatile acidities of the brine. When the homofermenter *Lactobacillus plantarum* dominated the entire fermentation, in contrast to a fermentation partially effected by heterofermentation, the quantity of volatile acid, and thus the ratio of volatile to nonvolatile acid, was low, and the total acid was low in relation to the pH. In one series of jars, for example, the average ratio of volatile to nonvolatile acid for four fermentations inoculated with *Lactobacillus plantarum* was .044, the average final acidity was 0.61, and the final pH 3.21, whereas another group of four inoculated with *Leuconostoc mesenteroides* yielded an average ratio of .116, average final acidity 0.95, and final pH 3.20. In a series of barrels when a total acidity of 0.50% was attained, the two brines inoculated with heterofermenters showed pH values of 3.79 and 3.73, whereas brines inoculated with homofermenters showed pH values of 3.59 and 3.50. In another series at total acidity of 0.50%, pH values of 3.58 and 3.81 for heterofermenters are contrasted to 3.49 obtained for homofermentation. In general, the heterofermentative inocula yielded higher pH values for a given total acidity. Since pH is the primary factor limiting growth, a high pH permits a higher total acidity. It should be noted, though, that subsequent additions of salt will lower the pH, and acidity-pH relationships will then be altered.

The results obtained with the jars for the three-year period showed that cucumbers inoculated with the heterofermenters or with the low-acid homofermenter *Streptococcus faecalis*, which favored the subsequent development of heterofermenters, invariably produced less bloating than those inoculated with the higher-acid homofermenters (Table 2).

Table 2. Summary of results in 1950, 1951, and 1952; showing effect of inocula on degree of bloating in 1-gal. jars.

Cultures used in inoculum	Total no. lots	No. lots without bloating	% bloated pickles
Streptococcus faecalis	36	14	6.5
Leuconostoc mesenteroides	35	21	4.6
Lactobacillus brevis	32	17	5.6
Pediococcus cerevisiae	34	14	11.3
Lactobacillus plantarum	35	9	14.3

In addition, those inoculated with heterofermenters more frequently yielded a gain in weight during curing. Although the cucumbers were not disturbed in the jars, the cucumbers inoculated with heterofermenters seemed to acquire the typical appearance of a fully cured pickle more rapidly than those inoculated with the homofermenters. This was verified in the studies in barrels.

In 1953, fifty 1-gal. jars of No. 4 pickles were packed and inoculated. The fully fermented, acid-cured cucumbers were uniformly superior, and all gained weight and showed no bloating, regardless of inocula used. Although analysis showed results similar to those previously obtained, no relationship to physical condition of the cucumber was observed.

Among the 11 series studied in barrels, 10 barrels were inoculated with broth cultures of *Leuconostoc mesenteroides*, 9 with *Lactobacillus brevis*, and 11 with *Lactobacillus plantarum*. The 18 others were considered to be controls. The results (Table 3) show that comparisons are only valid among replicates in a series. Furthermore, inoculation with heterofermenters, either *Leuconostoc mesenteroides* or *Lactobacillus brevis*, yielded the highest recovery of solid stock in 9 of the 11 series. The differences in many series are statistically insignificant. In one series, results were significantly better in the control than in that inoculated with *Lactobacillus plantarum*. In the studies in barrel lots, the effects of inocula in regard to dominance of flora, pH-acid relationship, and volatile-nonvolatile acid relationship were the same as in the small containers.

The fact that recovery of solid stock was usually higher when brine was inoculated with a heterofermenter is unimportant in itself. It is impractical to inoculate vats of cucumbers to ensure such fermentations. It should be noted, though, that low salt concentrations and low fermentation temperatures favor the natural development of the heterofermenting species.

Table 3. The effect of inoculation with pure cultures of lactic acid bacteria upon quality of pickle stock in barrels.

Date of packing	Lot no.	Size	Inoculum	Good stock		Cutting stock		Relish stock		Total stock	
				lb	%	lb	%	lb	%	lb	%
8-22-52	1	6	*L. plantarum*	82	37.8	124	57.1			206	94.9
	2	6	*Leuconostoc*	185	78.4	54	22.9			239	101.3
	3	6	Media	48	22.5	139	65.2			187	87.8
	4	6	Warm water	58	25.3	147	64.3			205	89.5
	5	6	Control	86	37.4	127	55.3			213	92.8
	6	6	Control	75	38.1	108	54.8			183	92.8
8-29-52	7	6	*Leuconostoc*	167	74.9	54	24.2	2	0.8	223	100.0
	8	6	*L. plantarum*	100	43.1	114	49.1	11	4.8	225	97.0
	9	6	Media	167	74.1	60	26.5	0	0	227	100.0
	10	6	Warm water	67	30.4	101	45.9	38	17.3	206	93.6
	11	6	Control	148	66.7	71	32.0	6	2.7	225	102.2
	12	6	Control	101	45.5	95	42.8	16	7.2	212	95.5
8-27-53	5	6	*L. brevis*	206	83.7	43	17.6			249	101.4
	6	6	*Leuconostoc*	229	95.2	28	11.6			257	106.6
	7	6	*L. plantarum*	200	86.6	38	16.6			238	103.2
	8	6	Control	187	75.6	59	23.9			246	99.7
9-3-53	1	5	Control	230	92.0	22	8.8			252	100.8
	2	5	*L. plantarum*	218	90.1	28	11.5			246	101.6
	3	5	*Leuconostoc*	237	94.4	20	6.0			257	102.4
	4	5	*L. brevis*	247	95.5	16	6.2			263	101.5
9-10-53	9	5 & 6	*L. brevis*	239	95.6	16	6.4			225	102.0
	10	5 & 6	*Leuconostoc*	212	95.7	17	7.9			230	103.6
	11	5 & 6	*L. plantarum*	222	95.5	12	4.9			234	100.4
	12	5 & 6	Control	232	93.0	19	7.4			251	100.4
8-17-54	1	6	*Leuconostoc*	133	57.3	87	37.4			220	94.9
	2	6	*L. brevis*	140	51.9	73	32.3	7	3.2	220	96.8
	3	6	*L. plantarum*	168	70.8	62	26.1			230	97.0
	4	6	Control	201	84.8	40	16.8			241	101.6
8-24-54	5	4	Control	28	12.1	191	82.6			219	94.8
	6	4	*L. brevis*	37	16.0	186	80.4			223	96.5
	7	4	*L. plantarum*	27	12.0	195	86.7			212	98.6
	8	4	Media	7	3.0	193	81.8			200	84.8
9-2-54	9	6	*Leuconostoc*	48	21.1	138	60.6	17	7.4	203	89.1
	10	6	*L. brevis*	9	4.0	186	83.4	7	3.1	202	90.5
	11	6	*L. plantarum*	30	13.2	158	70.0	2	0.8	190	84.0
	12	6	Control	13	5.8	179	81.3	9	4.1	201	91.3
9-9-54	13	6	*Leuconostoc*	45	20.4	154	69.9			199	90.2
	14	6	*L. brevis*	25	10.8	183	78.8			208	89.6
	15	6	*L. plantarum*	52	21.7	160	66.7			212	88.3
	16	6	Control	12	5.2	181	87.8			193	83.7
9-11-54	17	6	*Leuconostoc*	36	14.7	93	37.5	43	17.6	172½	71.0
	18	6	*L. brevis*	37	15.6	72	34.6	60	25.0	170	70.8
	19	6	*L. plantarum*	30	13.1	98	43.0	39	17.1	167	73.2
	20	6	Control	19	8.0	111	49.0	32	14.0	162	71.0

The significance of these observations should be examined further. It is noteworthy that in most series, the total recovery of pickle stock was usually lowest in barrels inoculated with *Lactobacillus plantarum*, in those in which warm water was added, and/or in controls, all conditions that may be favorable to a predominant homofermentation. It may be theorized, therefore, that the chemical and physical changes in cucumbers during a heterofermentation differ in some way from those in a homofermentation. Physical, chemical, and quality differences attributable to the nature of the fermentation have been observed by the authors in sauerkraut fermentations on numerous occasions. A poorly fermented sauerkraut, produced at high temperature or prepared by inoculation with *Lactobacillus plantarum*, has been observed to retain the raw cabbage texture and flavor and to show a low volatile acid content, coupled with a relatively low pH in relation to the total acid. Similarly, the cucumbers inoculated with *Lactobacillus plantarum* retained the typical cucumber appearance longer, and the brine had a low volatile acid content and low pH in relation to total acid.

The recovery of practically 100% solid stock from the jars of cucumbers packed in 1953 and the high percentage of recovery of good stock from barrels that year (Table 3), regardless of treatment, raise certain questions. Recovery of solid stock was poor in 1954. There is no doubt about the excellence of the stock in 1953. In 1953 the fermented stock of the largest size, over 2 in. in diameter, was excellent in appearance, meaty, and solid in the seed area. Few pickles contained well developed seeds. Weather conditions and relative physiological growth differences in 1953 may offer an explanation. During the active growing season of July, 1954, rainfall was only 0.91 in. In the same period in 1953, 3.73 in. was recorded. Reduced rainfall in July very likely affected growth conditions in 1954, resulting in greater maturity at a given size for that year. Absorption of salt by cucumbers was much more rapid in 1953 than in 1954 (Table 4). This was reflected by the relatively slower acid production and change in pH in 1954. It is possible that these measurable chemical differences are indications of other changes during fermentation that affect permeability. This prompted a study of

Table 4. Rate of salt absorption by cucumbers in 1953 and 1954 as shown by average per cent decrease in salt concentration of brine.

Year	No. of days in brine						
	0	1	2	3	4	6	10
1953	9.0	6.0	4.8	4.43	4.15	3.95	3.90
1954	9.0	7.6	6.9	6.25	5.45	5.05	4.40

mode of salt absorption by cucumbers in relation to other factors, particularly relative maturity.

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Effect of Active Carbon on the Storage Stability of Irradiated Meats [a]

(Manuscript received February 20, 1961)

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SUMMARY

This study was undertaken to evaluate the use of active carbon to improve the palatability of irradiated cooked (4.5 megarad) pork chops, pork loin, chicken parts, and beef rib-eye steak during storage at unrefrigerated temperatures. Preference score by a consumer-type panel improved when active carbon (0.2% by weight) was used with pork chops and chicken parts, but not with pork loin or beef steaks. Irradiated cooked chicken parts were stable at 22 and 38°C during a 16-month storage period. Beef rib-eye steaks, pork chops and pork loins were stable during 25 months at 22°C, whereas preference decreased with 38°C storage at 25 months with beef steaks and pork chops, and at 16 months with pork loin. During storage at 38°C, particularly after nine months, the pork and beef meats had a tendency to pull apart in the direction of the meat fibers. Preference ratings were "like moderately" for all products throughout storage.

LONG-TERM unrefrigerated storage of irradiated meats has been generally unsuccessful. Failures with raw meat in early experiments were due primarily to fat oxidation, enzymic spoilage, and flavor changes caused by irradiation itself. In time it was found that lipid oxidation could be minimized by using low oxygen tensions during irradiation and storage (Sribney *et al.*, 1955; Groninger *et al.*, 1956), and that a heat treatment at the time of processing would inactivate the meat enzymes (Drake *et al.*, 1957; Chiambalero *et al.*, 1959). Control of flavor changes has been more difficult, although some progress may well result from insights gained in continued experiments with freezing temperatures during irradiation (Ingram *et al.*, 1959).

A different approach to the flavor problem has been to incorporate packets of active carbon within the container to adsorb objectionable volatiles during storage. A panel of experts judged that the intensity of irradiation flavor of cooked beef was significantly lowered by such a carbon treatment (Tausig and Drake, 1959). It is generally believed that the taste of the products should improve as irradiation flavor is avoided, but no specific correlation has yet been established. Further, no report has been made on the effectiveness of carbon with other irradiated meats, particularly in relation to the extent that natural flavors might be adsorbed.

A study was made of the use of active carbon with irradiated cooked pork, chicken, and beef during storage. The meat products were evaluated by a consumer-type panel for the combined characteristics of flavor, appearance, and texture, rather than just the single parameter of irradiation flavor.

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EXPERIMENTAL

Material. The meats were fresh, chilled, standard-cut boneless pork loins, U. S. Good Grade beef rib-eye steaks, and U. S. Grade A broilers and fryers. The pork loins were trimmed of excess surface fat. For pork chops, the trimmed loins were cut into slices ½ in. thick. For pork loin roasts, the trimmed loins were paired, rolled, and tied with twine. The chicken parts used were thighs, legs, and breasts.

Enzyme-inactivation. The meat was placed in a single layer on screens and cooked in a saturated steam atmosphere at atmospheric pressure to an internal temperature of 74–79°C. Immediately thereafter it was cooled in circulating 4°C air to an internal temperature of 10°C or less.

Canning, freezing, and irradiation. Within an hour thereafter the product was filled into beaded No. 10 cans (603 x 700), and the cans were sealed under a vacuum of 7–12 in. Hg. A Viskon packet containing 4 g of active carbon (Nuchar C) was included in one-half of the cans of each meat item. Within 1 hr of being sealed, the cans were quick-frozen and held at −18°C. All cans were irradiated in the frozen state by fuel-rod gamma radiation (4.5-megarad dose) at Dugway, Utah, or at the Materials Testing Reactor Facility, Idaho Falls, Idaho.

Storage. The products were kept frozen at all times until put into 22°C or 38°C storage cabinets. The cans placed in storage were selected by use of a random sampling list.

Microbiological and toxicity testing. All irradiated samples were subjected to microbiological examination before taste-panel analysis. This consisted of a standard plate count, a qualitative test for anaerobes, and a 72-hour mouse injection *Clostridium botulinum* toxin assay. The samples opened for microbiological analysis were covered with aluminum foil and held 72 hr at 2–3°C before preparation for panel evaluation.

Preference evaluation. Samples of each product were evaluated at 0, 1, 4, 9, 16, and 25 months except that the chicken was used up at 16 months. Two cans per treatment were withdrawn for each evaluation so as to obtain a measure of product variability, i.e., two panels were used for each product at each evaluation period. Four samples—with carbon at 22 and 38°C storage, and without carbon at 22 and 38°C—were presented to each panel.

The consumer-type panel consisted each time of 20 subjects from a population of about 600 untrained persons who had agreed to test irradiated foods. Panel members were not specifically informed that the products were irradiated; they were told only what meat product was being presented. A nine-point hedonic scale was used (Peryam and Pilgrim, 1957), and salt and pepper were provided for use *ad libitum*.

The products were prepared for serving by appropriate cooking methods: steaks and chops were pan-fried, pork loins were roasted, and chicken parts were floured and deep-fat fried. Since these meats had been cooked already, browning and heating to a proper serving temperature were all that was required. All cooked samples were kept in a covered casserole at 140°F until served.

The data for each item were subjected to an analysis of variance. The statistical design for the sensory evaluation was a full factorial in which the in-can variable was confounded with the judge group.

RESULTS AND DISCUSSION

Tables 1 and 2 contain the results of the sensory evaluations, and analyses of variance. The most significant result is that all of the products received mean hedonic ratings in the range of "like moderately" throughout storage at either 22 or 38°C. Thus, the irradiated products were initially well-received by the consumer-type taste panel used, and had excellent storage stability properties.

The fact that the preference ratings did not markedly fluctuate or decline during storage could be due to a general lack of discrimination of the taste panels used. That the panel would discriminate, however, is indicated by a rating of 4.5 given the Can 2 38°C 25-month storage sample (inadvertently overcooked during preparation for serving) and by significant temperature-time interactions with the pork and beef products.

Those interactions occurred because the samples were less stable at 38°C than at 22°C. This was not apparent until the 16th month, however, and could be related to an increase in fragility of the meat during storage. Thus, a Hobart slicer could be used to slice the loins for serving in the early withdrawals, but by 16 months the meat tended to shred in the direction of the meat fiber and could be cut only with a sharp carving knife carefully used. A similar fragility was noted with both the pork chops and the beef steak; at 16 and 25 months, the slices easily broke into pieces during preparation. This was particularly troublesome with beef steaks stored at 38°C since the slices had molded together to present almost a solid mass of meat. The selection of only large pieces of meat to prepare and serve, however, may have tended to prevent the fragility in the chops and the steaks from being noted by the panel until 25 months.

Carbon packets improved the preference rating of pork chops and chicken parts, though only slightly, and its importance is difficult to assess. Such a small difference is not unexpected, however, as a reflection

Table 1. Mean hedonic ratings [a] by consumer-type panel for 4.5-megarad gamma-irradiated cooked meats stored for various periods.

Storage time (months)	Storage temperature			
	22°C (70°F)		38°C (100°F)	
	With carbon	Without	With carbon	Without
Pork chops				
0	7.2	7.0	6.8	7.0
1	7.0	6.7	7.2	6.8
4	6.7	6.5	7.5	6.7
9	7.6	6.7	7.3	7.0
16	7.5	7.0	6.9	6.9
25	7.5	6.4	6.4	6.1
Av.	7.3	6.8	7.1	6.8
Pork loin				
0	6.5	5.7	6.6	6.4
1	6.9	7.1	7.2	6.7
4	7.0	7.0	6.9	6.8
9	7.0	7.2	7.2	6.6
16	7.2	6.8	6.4	6.4
25	7.0	7.2	5.4 [b]	3.2
Av.	6.9	6.8	6.6	6.5
Chicken parts				
0	7.3	6.9	7.2	7.2
1	6.9	6.7	7.2	7.0
4	7.2	7.2	7.4	7.0
8	7.2	7.0	7.0	7.2
16	7.2	6.8	7.3	7.3
Av.	7.2	6.9	7.2	7.1
Beef rib-eye steak				
0	7.3	6.9	6.9	7.2
1	6.7	6.5	7.1	6.8
4	6.8	7.1	7.4	6.9
9	6.9	6.9	6.9	7.0
16	7.1	7.2	7.0	6.8
25	7.0	6.9	5.8	6.2
Av.	7.0	7.0	6.8	6.8

[a] Average of two panel means (20 evaluations/panel/can; 2 cans/treatment); scale of 9.

[b] Meat from one can overcooked during preparation; that panel mean was 4.5.

Table. 2. Analysis of variance.

Source	Pork chops				Pork loin		
	DF[a]	Mean sq.	F	Signif.	Mean sq.	F	Signif.
Carbon	1	43.7760	31.51	beyond 0.1%	2.2042	1.81	n.s
Temperature	1	1.5844	1.14	n.s.	25.3500	20.80	beyond 0.1%
Can (w/n time)[b]	6	4.7302	1.02	n.s.	6.5917	1.21	n.s.
Time (linear)[b]	1	4.9308	1.07	n.s.	0.1032	<1	n.s.
Carbon-temp.[c]	1	2.9260	2.11	n.s.	0.0667	<1	n.s.
Carbon-time [c]	1	8.1973	5.90	at 5%	11.7004	9.60	at 1%
Temp-time [c]	1	11.6358	8.38	at 1%	60.6229	49.75	beyond 0.1%
Carbon-temp.-time [c]	1	3.3951	2.44	n.s.	4.3667	3.58	at 1%
Judge [d]	228	4.6156			5.4327		
Judge-treatment [d]	684	1.3892			1.2185		
Total	959	2.31			2.46		

Source	Beef steaks				Chicken parts			
	DF[a]	Mean sq.	F	Signif.	DF[a]	Mean sq.	F	Signif.
Carbon	1	2.1094	1.47	n.s.	1	4.9612	4.66	at 5%
Temperature	1	7.5260	5.25	at 5%	1	5.2812	4.96	at 5%
Can (w/n time)[b]	6	3.8094	<1	n.s.	5	5.5512	1.30	n.s.
Time (linear)[b]	1	3.8258	<1	n.s.	5	1.5440	<1	n.s.
Carbon-temp.[c]	1	1.4260	<1	n.s.	1	0.5512	<1	n.s.
Carbon-time [c]	1	0.0151	<1	n.s.	1	0.6200	<1	n.s.
Temp-time [c]	1	36.4572	25.46	beyond 0.1%	1	4.7500	1.12	n.s.
Carbon-temp.-time [c]	1	3.2572	2.27	n.s.	1	0.5960	<1	n.s.
Judge [d]	228	4.8726			190	4.2545		
Judge-treatment [d]	684	1.4327			570	1.0645		
Total	959	2.38			799	1.88		

[a] Degrees freedom.
[b] Tested against judge.
[c] Tested against judge-treatment.
[d] Within group and with time.

of the relatively high preference ratings received throughout the storage period.

That carbon did not improve the ratings of the beef steak during storage is unexpected, particularly when one considers the rather dramatic decrease in intensity of irradiation odor during storage reported earlier (Tausig and Drake, 1959). However, 1% by weight of carbon was used in the previous study, and only 0.2% by weight in this one. Thus, it is possible that the small amount of carbon used here was not sufficient to adsorb the greater amount of "irradiation odor/flavor compounds" present in the beef products. This point must be studied further. On the other hand, the high preference ratings for the beef certainly tend to confirm the suggestion that the irradiation odor/flavor is not as predominant a factor in influencing flavor preference as has been thought (Drake *et al.*, 1960).

The panels evaluated only the "served" product. An additional desirable feature for the use of active carbon was its noticeable reduction of odors when the cans were first opened. This reduction was observed for all products through the first nine months. At 16 months, little difference in odor was noted between samples; indeed, all odors (both irradiation and natural) were markedly less than had been observed in earlier withdrawals.

The reason for the slightly significant temperature interaction (in which chicken parts held at the higher temperature were preferred) is not known. This result and the absence of a significant time interaction in all of the meat products considered as a group indicates that the typical rancidity one might expect (particularly in chicken and pork products) has not developed to any marked extent. Thus, the inherent storage stability of irradiated cooked meats has been demonstrated.

Acknowledgment

The assistance of Mrs. Beverly Kroll in designing and conducting taste-panel evaluations is gratefully acknowledged.

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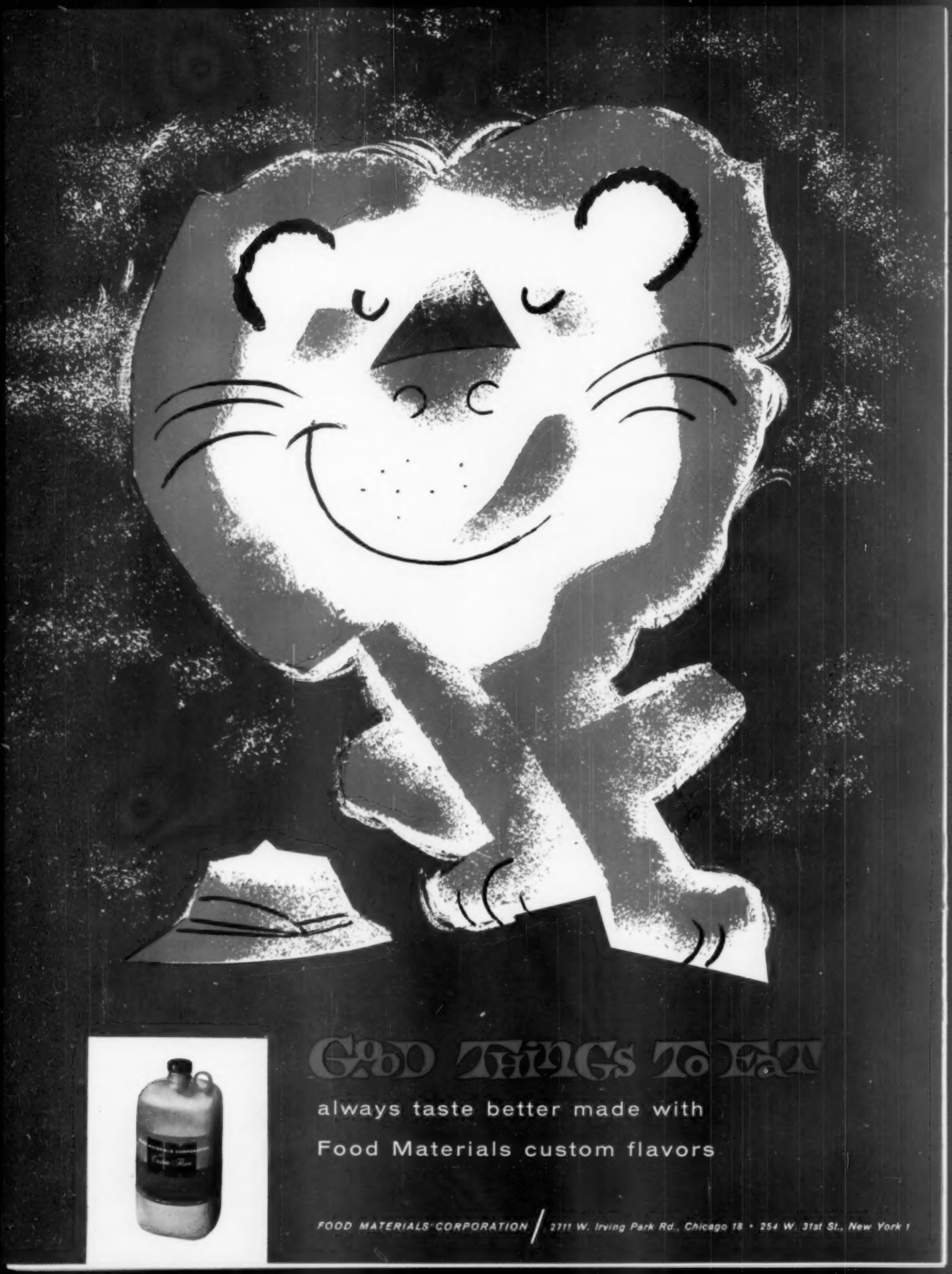
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Ultramicrodetermination of Mercury in Apples[a]

(Manuscript received March 11, 1961)

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SUMMARY

The concentrations of mercury were compared in apples sprayed with mercury-bearing fungicides and in unsprayed apples. There was a distinct uptake of mercury by the sprayed apples. The difference between sprayed and unsprayed apples in mercury content was somewhat more marked at the beginning of the growing season than at the end. There is a distinct downward trend in mercury content as the growing season progresses. The amount retained by sprayed apples at the end of the growing season is not of toxicological significance.

THE CONCENTRATION of mercury in apples was compared for orchards where mercury-bearing sprays were applied at the blossom stage and for orchards where mercury sprays were not used.

The literature on determining mercury in biological material was reviewed in a prior publication (Jacobs *et al.*, 1960). Since then, however, Gutenmann and Lisk (1960) used a modified Schöniger (1955) combustion and dithizone method with added mercury as a carrier, and Truhaut and Boudène (1959) described a method for determining mercury in animal biologic material requiring acid digestion, distillation, and titration with a chloroform solution of di-β-naphthylthiocarbazone. With particular respect to apples one can also mention the work of Arthrington and Hulme (1951) and the method detailed in the 9th edition of the *Methods of the Association of Official Agricultural Chemists*, 1960.

With special reference to ultraviolet photometry for estimation of mercury, one may cite the work of Woodson (1939), Ballard *et al.* (1954), Ballard and Thornton (1941), Zuehlke and Ballard (1950), Monkman *et al.* (1956), Lindström (1959), and Hemeon and Haines (1961).

For determining mercury in blood we recently developed a method that combines cold digestion, extraction with dithizone, decomposition of the mercury dithizonate by heating, and estimation of the mercury vapor elaborated by ultraviolet photometry. It is suitable for the milli- and centimicrogram range and can be performed with only 0.5–1.0 ml of blood. It appeared that this method might be modified for determining mercury in apples.

EQUIPMENT AND REAGENTS

Apparatus. An Osterizer type of blender was used since it could be taken apart completely for cleaning between preparation of each sample.

The combustion-ultraviolet photometric equipment consisted of a heating chamber connected to a U-tube containing non-absorbent cotton connected in turn to a cold trap, a rotameter, an additional cold trap, a modified Kruger mercury vapor meter Model 23, a water trap, and a water aspirator pump (Fig. 1). The mercury vapor meter was modified by replacing the grille with a cylindrical optical cell, 23 cm long and 4 cm in diameter, with removable silica end windows and inlet and outlet ports for the air stream drawn by the aspirator pump. The rotameter was a calibrated Fischer and Porter Flowrator equipped with both glass and stainless-steel floats. The water trap prevents any back-flow of water from the aspirator pump to the optical cell. The cold traps bring the temperature of the air stream down to room temperature.

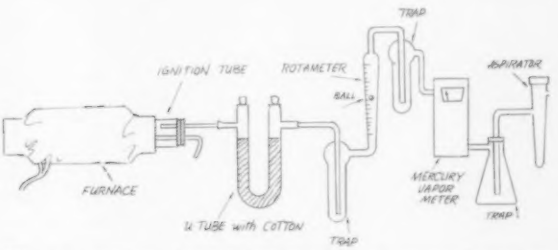

Fig. 1. Apparatus for the determination of mercury in apples.

The heating chamber consisted of a Bunsen burner mounted in a Nichrome wire cage $3\frac{3}{4} \times 3\frac{3}{4} \times 12$ in. Two cylindrical openings (1 in.) capable of accepting a 25×200-mm Pyrex ignition tube snugly were cut in opposite faces of the unit so that a Nichrome wire cylinder of 25 mm diameter could be placed about $6\frac{1}{2}$ in. from the bottom of the chamber and 2 in. above the top of the burner.

The glassware used included 125-ml glass-stoppered Erlenmeyer flasks, 125-ml separatory funnels, pipettes, 25-ml glass-stoppered graduated cylinders, and 25×200-mm Pyrex ignition tubes. For each run it was cleaned with cleaning solution, then washed with copious amounts of hot water, cold tap water, and distilled water, and was air or oven dried.

Reagents. *Dithizone extraction solution.*—Weigh out accurately 6 mg of purified diphenylthiocarbazone, transfer to a liter volumetric flask, dissolve in chloroform, and make to volume with that solvent.

6% potassium permanganate solution.—Dissolve 60 g of highest-purity reagent-grade potassium permanganate in distilled water with the aid of heat, transfer to a liter volumetric flask, allow to cool, and make to volume with distilled water.

Sulfuric acid.—The sulfuric acid used was concentrated reagent grade. The customary procedure was followed in preparing 0.25*N* sulfuric acid.

20% hydroxylamine hydrochloride solution.—Dissolve 200 g of reagent-grade $NH_2OH \cdot HCl$ in 500 ml of distilled water. Transfer to a separatory funnel and shake out with several 5-ml portions of the dithizone extraction solution. Draw off the chloroform layers and discard. Transfer the hydroxylamine hydrochloride to a liter volumetric flask and make to volume with distilled water.

Standard solutions. *Standard stock mercury solution.*—Weigh out exactly 0.1354 g of reagent-grade mercuric chloride and dissolve in 0.25*N* sulfuric acid. Transfer to a 100-ml volumetric flask and dilute to the mark with 0.25*N* sulfuric acid. This solution contains 1000 μg of mercury per milliliter.

Standard working mercury solution.—With a volumetric pipette transfer 1 ml of the stock standard mercury solution

[a] This investigation was supported in part by a PHS research grant RG 5977 from the National Institutes of Health, Public Health Service.

to a 100-ml volumetric flask. Dilute to volume with distilled water. Stopper, invert, and shake well. This solution contains 10 μg of mercury per milliliter.

With another volumetric pipette, transfer 1 ml of the 10 μg/ml mercury solution to a 100-ml volumetric flask and dilute to the mark with distilled water. Stopper, invert, and shake well. This working standard solution contains 0.1 μg/ml. These solutions must be prepared fresh as required.

PREPARATION OF STANDARD CURVE

Place 250 ml of 0.25*N* sulfuric acid in a separatory funnel with a dry stem. Add 1 ml of the 10 μg/ml working mercury standard solution, stopper, and mix. Extract with 5 ml of the dithizone extraction solution, shaking the separatory funnel for 1 minute, and allow the phases to separate. Swirl the contents of the funnel to make certain that all the chloroform solution is brought into the bottom phase. Release the pressure caused by the chloroform vapor through the mouth of the funnel, not through the stopcock. Transfer the clear extract to a dry 100-ml glass-stoppered volumetric flask, being careful not to draw any of the aqueous layer into the flask. Repeat the extraction twice with two more 5-ml portions of the dithizone extraction solution, and then extract once more with 5 ml of chloroform. Transfer each extract in turn to the 100-ml volumetric flask as before, and complete to the mark with chloroform. Stopper and mix thoroughly. Each milliliter of this solution contains 0.1 μg Hg as mercury dithizonate. With pipettes, transfer 0.2 ml of dithizone solution to each of two 25 × 200-mm Pyrex ignition tubes. These serve as blanks. With volumetric pipettes, transfer 0.1, 0.2, 0.3, and 0.4 ml of the chloroform-dithizone solution containing 0.1 μg Hg as dithizonate in duplicate to separate ignition tubes. The respective tubes will contain 0, 0.01, 0.02, 0.03, and 0.04 μg Hg in duplicate. Place the tubes in a beaker of hot water (70–80°C), and evaporate off the chloroform completely. Continue as detailed in the procedure.

Plot the maximum arbitrary scale reading, in milligrams per cubic meter multiplied by 1000, against μg Hg in the standards. The average curve obtained with 8 series of tests is shown in Fig. 2 as based on data in Table 1.

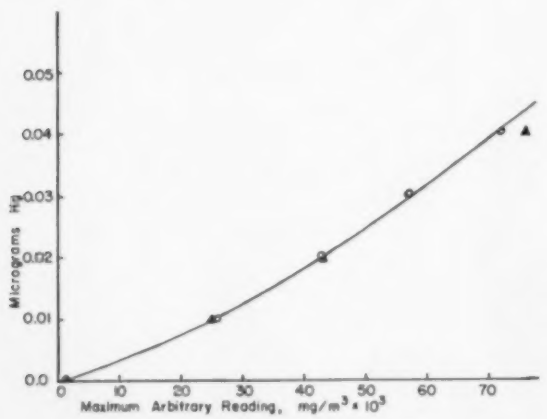

Fig. 2. Standard mercury curve.

Table 1. Average and range of standard curves obtained with known amounts of mercury.

Hg conc. (μg)	No. of detns.	Maximum arbitrary scale reading (mg/cu.m. × 10³)		
		Av.	Max.	Min.
0.	8	1	3	0
0.01	9	26	34	23
0.02	11	43	54	32
0.03	3	57	68	48
0.04	8	72	84	68

PREPARATION OF SAMPLE AND BLANK

Preparation of sample. The first two series were conducted on approx 100 g of Red Delicious and Stayman types and of the first set of McIntosh and Cortland. In later series, 1 apple was selected at random from each group.

The apples (stems removed) were cut into small pieces with a stainless-steel knife, and the pieces placed in the blender. Three ml of water was used for each gram of apple.

Sufficient water, generally 150 ml, was added to the blender to cover the apples. When the apples appeared uniformly disintegrated, the machine was turned off and the remainder of the water was added by washing down the sides of the container and the cover of the blender. Then the machine was operated 10 min and the contents transferred to a 500-ml glass-stoppered flask.

Preparation of blank. Before each series of determinations a blank was run on the distilled water. After 250 ml of the water was mixed in the blender for several minutes, it was transferred to a 250-ml volumetric flask. Twenty ml was then transferred to a 125-ml glass-stoppered flask and used for the blank determination.

PROCEDURE

Immediately after the sample is prepared and transferred to the 500-ml glass-stoppered flask, transfer 10 ml with a calibrated graduated cylinder to a 125-ml glass-stoppered Erlenmeyer flask. Wash out the cylinder with 10 ml of water. If greater accuracy is desired weigh out 10 g of the prepared sample, transfer to a 125-ml glass-stoppered flask, wash the weighing vessel with 10 ml of water, and add the washings to the flask. Each 10-ml or 10-g aliquot contains 2.5 g of apple. Add 20 ml of 6% potassium permanganate solution, and add 4 ml of concentrated sulfuric acid dropwise, swirling the contents from time to time. Treat the blanks in the same manner. Warm on a hot plate set at low heat (do not boil or simmer), remove from the hot plate, swirl, and allow to stand 15 min. The mixture will, in general, be decolorized. Add an additional 10 ml of 6% potassium permanganate. Repeat the warming on the hot plate, removing, swirling, and cooling two more times. Allow to stand until the supernatant solution is clear or for a total elapsed time of one hour. Dissolve the precipitate with sufficient 20% hydroxylamine hydrochloride solution. Swirl to assist in dissolving the precipitate. Stopper the flask, shake, release the pressure cautiously, and allow to stand 10 min. If more 20% hydroxylamine hydrochloride solution is required to dissolve the precipitate, add drop by drop.

Transfer the solution to a dry 125-ml separatory funnel with a dry stem. Wash the Erlenmeyer flask with three 10-ml portions of distilled water, add the washings to the separatory funnel, and mix. Add 5 ml of the dithizone extraction solution. Stopper the separatory funnel and shake vigorously for 1 min. Release the pressure through the mouth. Swirl to bring down any chloroform droplets, and allow to stand until the phases separate completely. Draw off the chloroform layer into a glass-stoppered 25-ml graduated cylinder, being careful not to draw off any of the aqueous layer. Repeat the extraction with 5 ml more of dithizone extraction solution, and then wash with 3 ml of pure chloroform. Add the chloroform wash to the graduated cylinder. Add sufficient chloroform directly to the cylinder to make the total volume 15 ml.

With a pipette and safety pipetter, transfer 1 ml of the chloroform solution of mercury dithizonate to a 25 × 200-mm Pyrex ignition tube and place in a hot-water bath. Evaporate off the chloroform completely at 70–80°C.

While the chloroform is being evaporated check the apparatus, turn on the Kruger mercury vapor meter, allow it to warm up for 20 min, turn on the aspirator pump so that the air flow is about 3300 ml per minute, and allow the instrument to come to equilibrium. Check the span of the instrument. After all the chloroform has evaporated, dry the outside of the tube and insert the ignition tube into the heating unit, placing it so that the flame will heat the bottom end of the tube. Light a match, insert it into the lighting opening, turn on the gas, allow it to ignite, remove the match, and start a stop watch. Record the starting time, in seconds, of the meter

needle, the maximum deflection of the meter needle (meter reading at 10-sec intervals, if possible), and the time of return of the meter needle to zero. Obtain the concentration from the standard curve.

Calculation. Multiply the value in μg Hg obtained from the standard curve by 15 to obtain total mercury in the 2.5-g sample, and then by 40 to give the concentration in 100 g of apple. Divide this value by 100 to express the results in parts per million on a weight/weight basis. The reading from the standard curve can be multipled, of course, by 600 to yield directly the concentration in μg per 100 g of apple.

RESULTS

Stayman and Red Delicious varieties of apples were sprayed at the beginning of the growing season (June 29, 1960) with a solution containing 0.5 pint of an alkyl mercurial per 100 gallons. No spray was used thereafter. Sample apples were picked then and on July 11, July 19, July 29, August 8 (i.e., 10-day intervals), and at harvest, September 7, 1960. Check samples from orchards of the same varieties that had not been sprayed were picked on the same dates. Analyses for Stayman and Red Delicious are in Table 2.

Table 2. Concentration of mercury in sprayed and unsprayed Stayman and Red Delicious apples.

Variety and series	Date picked (1960)	Apples		Mercury (ppm)
		No.	Weight (g)	
Stayman, sprayed[a]				
1	6/29	3	108	0.12
2	7/11	3	100	0.17
3	7/19	2	120	0.22
4	7/29	1	95	0.12
5	8/8	1	102	0.11
6	9/7	1	112	0.06
6	9/7	1 (washed)	114	0.07
Stayman, unsprayed				
1	6/29	3	110	0.06
2	6/11	3	100	0.03
3	7/19	2	120	0.06
4	7/29	1	95	0.03
5	8/8	1	100	0.04
6	9/7	1	116	0.01
Red Delicious, sprayed[a]				
1	6/29	3	100	0.17
2	7/11	3	100	0.08
3	7/19	2	120	0.09
4	7/29	1	90	0.11
5	8/8	1	116	0.11
6	9/7	1	113	0.09
6	9/7	1 (washed)	106	0.06
Red Delicious, unsprayed				
1	6/29	3	100	0.16
2	7/11	3	104	0.07
3	7/19	2	116	0.10
4	7/29	1	98	0.02
5	8/8	1	102	0.15
6	9/7	1	110	0.01

[a] Sprayed on June 29, 1960 with a solution containing 0.5 pint of an alkyl mercurial per 100 gal.

Samples of McIntosh and Cortland apples were also analyzed. One group of each of these varieties was sprayed with 0.5 pint of 10% aromatic mercurial per 100 gallons of spray, a second group with another aromatic mercurial at the same rate, and a third group with a different aromatic mercurial. One set of unsprayed apples was analyzed.

In all, 69 apples representing 39 samples were analyzed. The maximum concentration was 0.22 ppm, found in the third series of the Stayman variety. Next was 0.17 ppm, found in the first series of Red Delicious and second series of Stayman. In sprayed apples the maximum concentration at the end of the growing season was 0.09 ppm (Red Delicious) for all varieties tested. For unsprayed apples the maximum at the end of the growing season was 0.08 ppm (an outside check of McIntosh) and 0.08 ppm for a Cortland checker control. The maximum for the Stayman unsprayed checks was 0.06 for the entire test, whereas for the Red Delicious checks the maximum was as high as 0.16 ppm.

DISCUSSION

The method of Jacobs *et al.* (1960) for determining mercury in blood was adapted for apples. The portion taken for the analysis must be somewhat larger because suspending the cellular matter of apples uniformly is difficult. The larger quantities required more potassium permanganate solution and more sulfuric acid. The sulfuric acid must be added with great care since the apples contain sugar and the reaction is vigorous when the sulfuric acid is added.

The results indicated that recovery was of the same order of magnitude as with blood, so that no further testing was done. In addition, the results of analysis were on the same order of magnitude as those of Gutenmann and Lisk (1960).

There is a distinct downward trend in the concentration of mercury as the growing season continues (Figs. 2, 3). The average final concentration of mercury was 0.055 ppm in sprayed apples (10 samples), and 0.037 ppm in unsprayed and checker controls. The average final concentration was 0.07 ppm for the sprayed Stayman and Red Delicious varieties, and 0.01 ppm for the unsprayed. Uptake of mercury by sprayed apples over unsprayed apples thus averaged

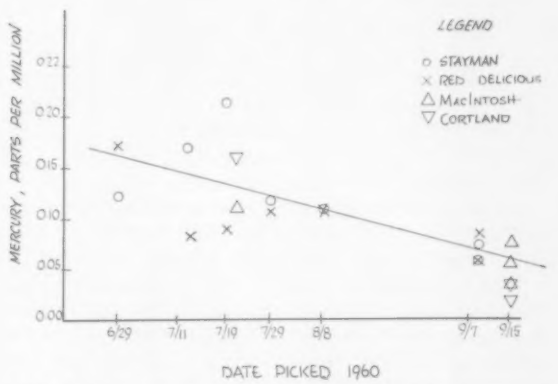

Fig. 3. Decrease in mercury concentration with increase in size of sprayed apples as growing season progresses.

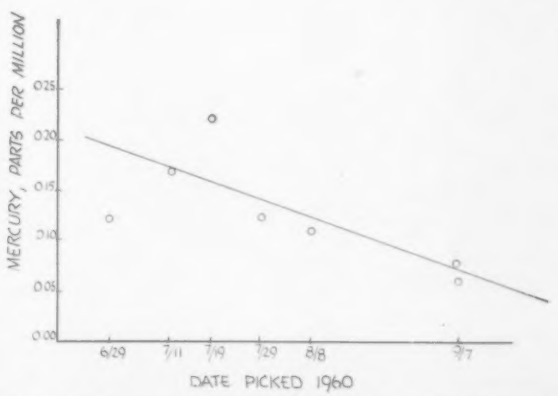

Fig. 4. Decrease in mercury concentration with increase in size of sprayed Stayman variety apples as growing season progresses.

Table 3. Concentration of mercury in sprayed and unsprayed McIntosh and Cortland apples.

Variety and series	Date picked (1960)	Treatment	Apples		Mercury (ppm)
			No.	Wt.(g)	
McIntosh					
1	7/20	Checker control	4	160	0.04
2	7/20	Sprayed [a]	4	146	0.11
1	9/15	Checker control	1	116	0.006
2	9/15	Sprayed [a]	1	108	0.06
5	9/15	Sprayed [b]	1	140	0.04
9	9/15	Sprayed [c]	1	136	0.08
..	9/15	Outside check	1	112	0.08
Cortland					
5	7/20	Checker control	3	183	0.02
6	7/20	Sprayed [a]	3	154	0.16
1	9/15	Checker control	1	138	0.08
2	9/15	Sprayed [a]	1	138	0.04
5	9/15	Sprayed [b]	1	122	0.04
9	9/15	Sprayed [c]	1	105	0.01

[a] Sprayed with 0.5 pint of a 10% aromatic mercurial per 100 gal.
[b] Sprayed with 0.5 pint of an aromatic mercurial per 100 gal.
[c] Sprayed with 0.25 pint of an aromatic mercurial per 100 gal.

0.02 ppm (2 parts per hundred million) for all the apples analyzed, and 0.06 ppm (6 parts per hundred million) for Stayman and Red Delicious.

Though unsprayed Stayman apples had a maximum initial concentration of 0.06 ppm, Red Delicious had two samples with as high as 0.15 to 0.16 ppm, considerably higher than the concentrations in sprayed apples at the end of the growing season. Washing the sprayed apples made little difference.

To consider the toxicological question briefly one may refer to the threshold limit or maximum allowable concentration (MAC) for organic mercury for an 8-hr working day: 0.01 mg per cubic meter of air. Assuming that a worker breathes in 10 cubic meters of air per working day and that all of the mercury in the air is absorbed, total absorption of mercury will be 0.1 mg. To absorb 0.1 mg of organic mercury from apples containing 0.055 ppm, a person would have to consume 1,818 g of apples (over 4 lb) per day. Since the MAC for inorganic mercury is 0.1 mg per cubic meter, ten times that weight of apples would have to be consumed to absorb the 1-mg equivalent to one working day. It is unlikely that apples containing this concentration, or any concentration found at the end of the growing season in this study, could be of health significance.

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Experiments on Preservation with a New Ice Containing Glycol Diformate and Sorbic Acid

(Manuscript received February 20, 1961)

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SUMMARY

Ice containing glycol diformate (200–400 ppm) and sorbic acid (100 ppm) was compared with common ice and the acronizing process on chickens. Quality of the stored product was measured at intervals for 3–4 weeks by organoleptic test, bacterial count, and three chemical tests. The diformate ice appears to be superior to both common ice and the acronizing process. An earlier experiment on crawfish with the new ice and common ice also proved the superiority of the new ice in controlling bacterial growth and in preventing the loss of urea.

SEVERAL attempts have been made during the last 40 years to prepare germicidal and eutectic ices (Tarr, 1946). The chemicals that have been incorporated in germicidal ice include calcium hypochlorite, dichloramine, benzoic acid, formaldehyde, hydrogen peroxide, sodium propionate, and sodium nitrite. Used in eutectic ices were sodium chloride, sodium bicarbonate, disodium phosphate, and sea water. Tarr *et al.* (1954) employed 15 antibiotic substances in germicidal ices and found tetracycline, oxytetracycline, and chloramphenicol to be most effective. Abbey *et al.* (1960) reported chlortetracycline to be the most effective antibiotic in ice for poultry preservation.

The interest of the senior author in germicidal ices dates from 1944, when he conceived the idea of exploiting the higher effectiveness of preservatives when in the state of generation (status nascendi). This led to the preparation of ice containing glycol diformate, which on melting in contact with the product would liberate formic acid and glycol in the state of generation. Results were encouraging when the new ice was tried with cultures of *Escherichia coli* and with fish (Kaloyereas, 1946).

In 1952 the glycol diformate ice was improved by the addition of sorbic acid. In 1955 the germicidal ice was further modified by the addition of sulfanilamide, and a French patent was obtained (Kaloyereas, 1956a).

In the study reported here the new diformate ice was compared with common ice and with the commercially established "acronizing" process.

EXPERIMENTAL METHODS

Experiments were carried out with fresh live crawfish, and freshly killed and dressed chickens weighing 2–2.5 lb.

In the experiment with crawfish, large Dewar flasks were provided with horizontal wooden partitions with holes to allow the water of the melting ice to drain away from the crustaceans. In separate flasks, live crawfish were packed in common ice and in glycol diformate–sorbic acid ice containing 200 ppm of each. At the beginning of the experiment and during storage, quality tests were made as indicated in Table 1 and described below.

In the work with chickens, four experiments were conducted on 20–40 chickens in each. In the first experiment, 32 fryers were used, cut in halves. Four insulated metallic boxes with perforated bottoms, each containing 16 halves of chickens, were packed with: 1) simple flake ice; 2) flake ice containing 100 ppm glycol diformate, 100 ppm sorbic acid, and 30 ml concentrated HCl per ton; 3) common flake ice after acronizing treatment; and 4) with diformate flake ice after acronizing treatment. (Acronizing treatment consisted in dipping the chicken for 30 min in a solution of chlortetracycline (10 ppm) according to instructions given by American Cyanamid Company in its Tech. Bull. No. 10.) The HCl was added to create more favorable conditions for the action of the sorbic acid. The insulated metallic boxes were placed at room temperature, and additional ice was supplied daily as required.

In the second experiment whole chickens were used and the glycol diformate ice employed was frozen in blocks and crushed for use in packing the chickens. Hydrochloric acid was not used in the preparation of the ice.

In the third experiment the diformate ice was prepared as in experiment 1 except that the glycol diformate was increased to 400 ppm.

Experiments were also conducted to evaluate possibilities of using the new ice formula in solution for dips in the preservation of chickens in ordinary cold storage. Whole chickens and chickens cut in pieces were dipped in freshly prepared solutions, containing 200 ppm glycol diformate, 100 ppm sorbic acid, and 1.5 ml conc HCl per 100 lb of water. The samples were placed in stockinets and Cryovac bags and stored in common ice and in air at 33°F (Table 4).

Four chemical tests of quality were employed:

1) The phosphate stability test was that described by Kaloyereas (1954, 1956b). A 5-g sample of the lean meat was blended in a Waring blender and filtered through paper, and to 50 ml of the filtrate was added 1 ml of freshly prepared 5% tannic acid solution. The material was filtered again, and 25 ml of the protein-free filtrate was titrated from pH 4.3 to 3.1 [the range of titration of monocalcium phosphate, $Ca(H_2PO_4)_2$] with $N/10$ HCl. The titration value divided by pH change (1.2) and by 10,000 was multiplied by 80 to give the value per 100 g of meat. This value is expressed as dB/dpH in the tables.

2) Sulfhydryl groups were determined on the protein-free filtrate by the method of Glick (1954). Readings were made on

Table 1. Results of quality tests on crawfish stored in common ice and in the new glycol diformate-sorbic acid ice (200 ppm of each).

	$\frac{dB}{dpH}$	Urea (mg/100 g)	Bacterial count (per g)
Fresh alive	0.54	70	2,900,000
Stored in common ice:			
After 1 week	0.0040	0.0	119,000,000
After 25 days			765,000,000
Stored in the new ice:			
After 1 week	0.0052	60	22,000,000
After 25 days			316,000,000

NOTE: The crawfish in the common ice were alive until the fifth day of storage, whereas in the new ice they remained alive for about two weeks. In the common ice the crawfish showed signs of deterioration on the tenth day of storage; in the new ice similar signs appeared only after the third week of storage.

Table 2. Results of quality tests on chicken stored in various ices.

Treatments	Phosphate stability[a] $\frac{dB}{dpH}$	—SH groups[a] color at 520 mμ	Protein hydrolysis color at[a] 440 mμ	Bacterial count[a] per g	Organoleptic test[b]	Sum of all ratings
A First experiment						
a) Stored 10 days						
1) Common ice	0.0034[5]	97[4]	276[5]	3,860,000[5]	36.3[5]	24[5]
2) New ice[c]	0.0058[2]	93[3]	139[2]	417,000[4]	40.6[2]	14[2]
3) Acron in common ice	0.0040[4]	121[5]	225[4]	27,000[3]	40.0[4]	20[4]
4) Acron in new ice	0.0043[3]	85[1]	198[3]	222[1]	42.3[1]	9[3]
5) Fresh (control)	0.0088[1]	91[2]	103[1]	3,570[2]	41.6[2]	8[1]
b) Stored 20 days						
1) Common ice	0.0030[4]	135[5]	172[3]	722,000[4]	32.0[5]	21[4]
2) New ice	0.0040[2]	104[3]	155[2]	153,000[3]	33.6[4]	12[2]
3) Acron in common ice	0.0017[5]	130[4]	195[4]	700,000[3]	35.6[2]	18[3]
4) Acron in new ice	0.0035[3]	101[2]	292[5]	5,110,000[5]	34.3[3]	18[3]
5) Fresh (control)	0.0060[1]	99[1]	132[1]	1,100[1]	46.0[1]	5[1]
c) Stored 30 days						
1) Common ice	0.0040[4]	115[1]	434[4]	7,700,000[5]	19.0[5]	19[4]
2) New ice	0.0052[1]	117[2]	339[2]	1,100,000[2]	25.8[3]	10[2]
3) Acron in common ice	0.0032[5]	125[4]	460[5]	3,600,000[3]	25.4[4]	21[5]
4) Acron in new ice	0.0034[3]	118[3]	401[3]	6,900,000[4]	27.0[2]	15[3]
5) Fresh (control)	0.0050[2]	117[2]	233[1]	22,300[1]	43.0[1]	7[1]
B Second experiment						
a) Stored 1 week	0.0041[2]	115[4]	204[4]	730,000[4]	40.5[2]	17[4]
1) Common ice	0.0040[3]	104[1]	163[3]	700,000[3]	41.6[3]	11[2]
2) New ice[d]	0.0040[3]	108[3]	173[3]	230,000[2]	39.0[4]	15[3]
3) Acron in common ice	0.0048[1]	105[2]	160[1]	less than 100[1]	43.8[1]	6[1]
4) Fresh (control)						
b) Stored 2 weeks	0.0056[3]	121[4]	200[3]	165,000,000[4]	39.2[4]	18[4]
1) Common ice	0.0060[2]	108[2]	145[2]	58,000,000[3]	43.2[2]	11[2]
2) New ice	0.0053[4]	120[3]	134[1]	11,000,000[2]	42.3[3]	13[3]
3) Acron in common ice	0.0096[1]	97[1]	145[2]	176,000[1]	44.3[1]	6[1]
4) Fresh (control)						
c) Stored 4 weeks	0.0031[4]	163[4]	210[4]	573,000,000[3]	18.0[4]	18[4]
1) Common ice	0.0037[3]	152[3]	165[3]	784,000,000[3]	25.3[2]	13[3]
2) New ice	0.0044[2]	130[2]	178[3]	841,000,000[4]	25.0[3]	14[3]
3) Acron in common ice	0.0069[1]	119[1]	98[1]	20,000[1]	40.1[1]	5[1]
4) Fresh (control)						
C Third experiment						
a) Stored 1 week						
1) Common ice	0.0043[4]	114[4]	163[1]		36.7[3]	12[4]
2) New ice[e]	0.0051[2]	98[1]	163[1]	Not done	36.0[4]	8[2]
3) Acron in common ice	0.0049[3]	107[2]	195[3]		37.0[2]	11[3]
4) Fresh (control)	0.0058[1]	105[2]	185[3]		37.5[1]	7[1]
b) Stored 2 weeks						
1) Common ice	0.0040[3]	112[3]	182[3]	66,000,000[4]	37.7[1]	13[3]
2) New ice	0.0043[2]	102[2]	185[3]	7,560,000[3]	35.0[3]	13[3]
3) Acron in common ice	0.0029[4]	115[4]	200[4]	3,650,000[2]	33.7[4]	18[3]
4) Fresh (control)	0.0060[1]	100[1]	172[1]	107,000[1]	35.7[2]	6[1]
c) Stored 4 weeks						
1) Common ice	0.0032[4]	150[3]	335[3]	1,000,000,000[3]	28.0[3]	16[3]
2) New ice	0.0037[3]	106[2]	163[2]	470,000,000[2]	31.0[2]	9[2]
3) Acron in common ice	0.0036[3]	163[4]	340[4]	1,200,000,000[4]	27.0[4]	19[4]
4) Fresh (control)	0.0072[1]	105[1]	193[1]	150,000[1]	40.0[1]	6[1]

[a] Superscript numbers show how the particular quality rated among the group of treatments at the same storage period.
[b] Av. of rating for odor, flavor, juiciness, color, tenderness.
[c] Flake ice containing 100 ppm glycol diformate, 100 ppm sorbic acid, and 30 ml HCl conc per ton.
[d] Same as footnote c except that the HCl was omitted and the germicidal ice was frozen in blocks.
[e] Same as in footnote c except that glycol diformate was increased to 400 ppm.

the Klett-Summerson colorimeter at 520 mμ. The values in the tables are the differences between the sample and the blank.

3) The protein hydrolysis test was the xanthoproteic reaction described by Morrow (1927). The test was made using 3 ml of the protein-free filtrate; values in the tables are differences between sample and blank read at 440 mμ.

4) Urea nitrogen determinations (made on crawfish) were by the method described by Harrow (1944).

For the determination of bacteria, parts of chicken (wing) were weighed and placed in a wide-mouth screw-cap bottle, 100 ml of sterile distilled water was added, and the bottle was shaken vigorously for 2 min to dislodge bacteria from the skin surface; there was no tissue disintegration. The bottle was allowed to stand 5 min, and again shaken for 1 min. Decimal dilutions were prepared in distilled water, and duplicate plates of appropriate dilutions were prepared with tryptone glucose extract agar. Colonies were counted after incubation for 4 days at 24–28°C.

Crawfish were examined in the same way except that the weighed samples (3 crawfish) were placed in a blender jar, sterile water was added to give a dilution of 1:10, and the sample was disintegrated for 2 min in a Waring blender. The sample was allowed to stand a few minutes before samples were removed for the preparation of dilutions for plating.

For the organoleptic tests, samples of chicken stored and freshly killed, raw and after frying, were examined for odor, flavor of lean, flavor of fat, color, juiciness, and tenderness. Each quality was rated from 2 to 8, and the maximum possible score was 48.

RESULTS AND DISCUSSION

The results with crawfish (Table 1) indicate that the glycol diformate ice was more effective than common ice in preventing loss of urea, and in the inhibition of bacterial growth. The phosphate stability was also slightly greater with the diformate ice.

The experiments with chickens (Table 2) show that in all cases but one the over-all rating of the meat stored in the diformate ice was second only to the fresh chicken. In one instance the chicken acronized and stored in diformate ice was rated second to the

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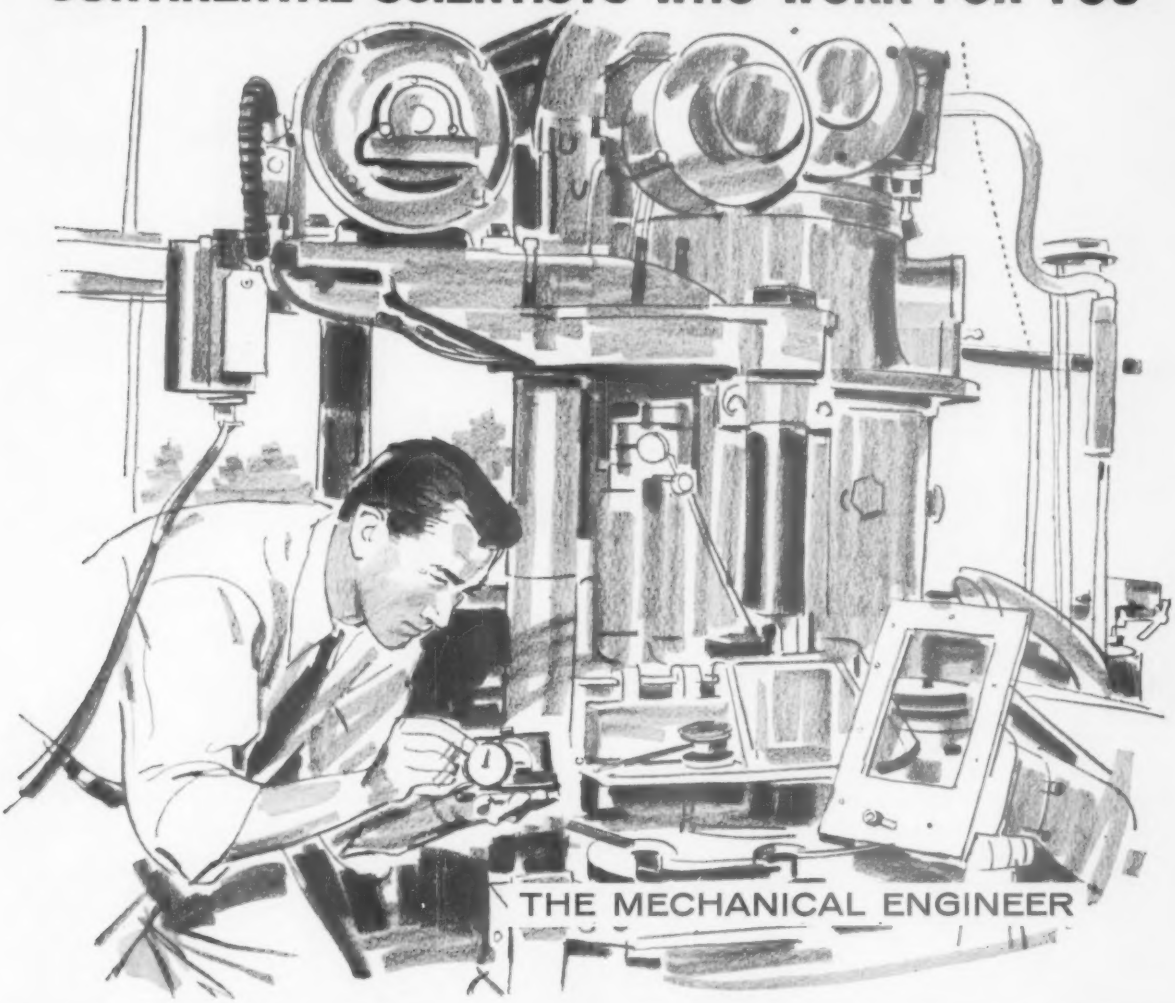

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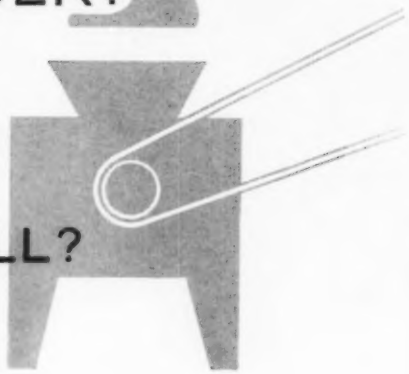

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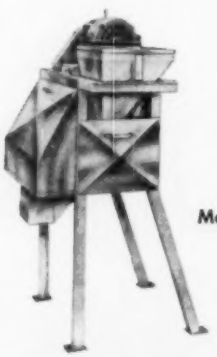

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Table 3. Organoleptic rating of chicken stored in ice.

Treatment	Number of times rated as No. 1	No. 2	No. 3	No. 4	% of samples scored 1 or 2
Common ice	3	4	13	29	14
Diformate ice	5	27	13	4	65
Acronized[a]	1	8	17	23	18
Fresh control	38	11	0	0	100

[a] Dipped in 10 ppm chlortetracycline 30 min and stored in common ice (Bull. No. 10, American Cyanamid Co.).

fresh chicken. In every case but three the chicken stored in common ice was given the lowest over-all rating based on the 5 quality tests employed. Table 3 shows organoleptic ratings of the various methods of storage of chickens. Most of the samples stored in

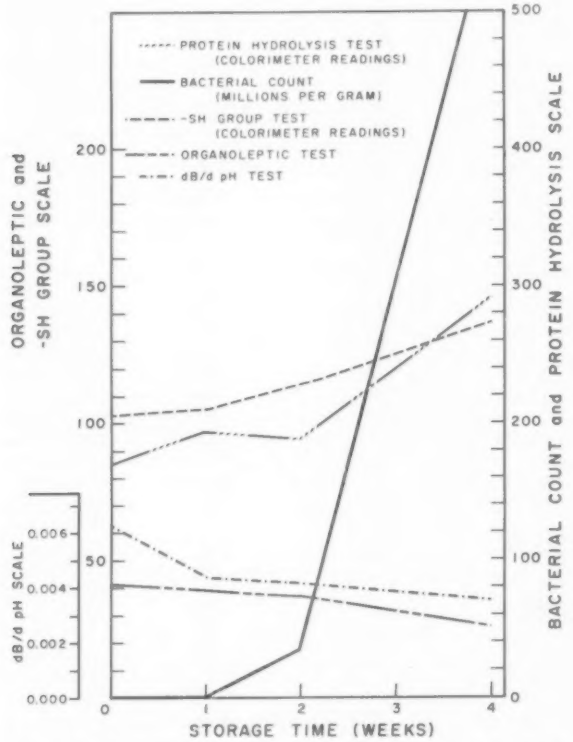
PROTEIN HYDROLYSIS TEST (COLORIMETER READINGS)
BACTERIAL COUNT (MILLIONS PER GRAM)
-SH GROUP TEST (COLORIMETER READINGS)
ORGANOLEPTIC TEST
dB/d pH TEST
ORGANOLEPTIC and -SH GROUP SCALE
BACTERIAL COUNT and PROTEIN HYDROLYSIS SCALE
dB/d pH SCALE
STORAGE TIME (WEEKS)

Fig. 1. Comparative trend in changes of chemical, bacterial count, and organoleptic tests.

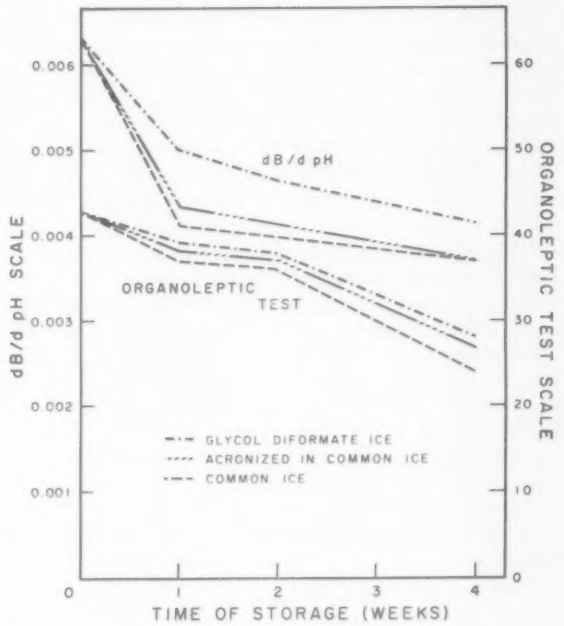

Fig. 2. Comparison of the three treatments on the basis of organoleptic and phosphate stability tests.

the glycol diformate ice scored in the first or second place (before or after the fresh chickens). A more comprehensive comparison is obtained by looking at the graphs where the trend of changes during the storage with the various treatments is shown, and also the average values obtained with the various tests during the storage are shown in comparison with the values obtained with the organoleptic test (Figs. 1 and 2). Except for the protein hydrolysis test, which shows some irregularity between the first and second examination, all the other tests by these results seem more or less appropriate to be used as quality tests for chicken. For their full and accurate evaluation, however, as quality tests in general, more experiments are needed on each of the above chemical tests. For those interested in the study of these tests on new products as well as on chickens, we wish to give the following information.

The phosphate stability test was first worked out as

Table 4. Results of organoleptic tests of chicken (average rating of five judges).

Treatment	Odor	Flavor of lean	Flavor of fat	Tenderness	Color	Juiciness	Total score
a) Results at the end of two weeks' storage							
1) Whole chicken in stockinet stored in common ice	6	6	6	6	6	6	36
2) Whole chicken dipped[a] placed in stockinet stored in common ice	6	7	7	7	7	7	41
3) Chicken in pieces in stockinet stored in common ice	6.5	5	5.5	5.5	6	5.5	33.5
4) Chicken in pieces, dipped,[a] placed in stockinet stored in common ice	6	7	7	6.5	7	6.5	37.5
5) Chicken in pieces, dipped,[a] placed in Cryovac bags stored at 33°F	8	8	8	8	8	8	48
6) Fresh chicken	8	8	8	7	8	7	46
b) Results at the end of three weeks' storage							
No. 5 chicken dipped,[a] placed in Cryovac bags	8	8	8	7	8	8	47
No. 6 fresh chicken	8	8	8	7	8	8	47
No. 1, 2, 3, and 4 were not suitable for organoleptic tests after storage for 3 weeks.							

[a] Immersed 30 min in solution consisting of 200 ppm glycol diformate, 100 ppm sorbic acid, and 30 ml HCl.

a test for heated milk (Kaloyereas, 1954). Later its use was extended to thermostabilized eggs, and tentatively to other products (Kaloyereas, 1956b, 1958). Recent investigations by Neuberg *et al.* (1957) point out the importance of the reaction involved in the test in the cycle of calcium and phosphorus in nature. The explanation that might be given for the operation of the test as a criterion of quality is as follows:

The progressive diminution of life in the cells during the storage causes a progressive decrease of carbonic acid in the medium, which causes the shifting of equilibrium between phosphates toward dicalcium and tricalcium from monocalcium phosphate. The test of sulfhydryl groups is based on the idea that the presence of such groups is associated with some denaturation of the protein molecule. The xanthoproteic reaction refers to the presence of amino acids containing the benzene ring. Since the test was made on the protein-free filtrate, it is assumed that it will indicate the extent of hydrolysis taking place during storage.

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Chemical Composition of Potatoes. II.

Relationship of Organic Acid Concentrations to Specific Gravity and Storage Time

(Manuscript received April 25, 1961)

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SUMMARY

Maine Katahdin potatoes were analyzed monthly during 8 months at 38°F followed by one month at 45°F and one month at 50°F. Glutamic, aspartic, pyroglutamic, malic, citric, oxalic, and phosphoric acids were determined. Potatoes of high specific gravity contained more citric acid and less pyroglutamic, malic, and phosphoric acids than did tubers of low specific gravity. Changes during storage were considerable relative to the amounts of acid present; most of the acids showed either a maximum or a minimum concentration after one or two months. Higher storage temperatures caused no significant change in the acid content of the tubers, but the resulting sprouts showed a markedly different pattern of acid concentrations.

THE AVAILABILITY of potatoes as a fresh, and to a lesser extent as a processed, vegetable depends on the efficiency of storage methods in preserving palatability and nutritive value and in regulating changes in composition. Studies of compositional changes in potatoes of various specific-gravity levels during storage may provide an insight into such changes and the problems resulting when processing industries use stored potatoes. Investigations of

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changes during storage have been concerned mainly with carbohydrates and total solids (Schwimmer *et al.*, 1954; Treadway *et al.*, 1949) and with nitrogenous fractions (Cotrufo and Levitt, 1958; Stuart and Appleman, 1935), but very little with organic acids, in spite of the central role that these compounds play in metabolism (Burris, 1953; Thimann and Bonner, 1950). Because of its nutritional importance, ascorbic acid has been studied somewhat extensively, e.g., Leichsenring *et al.* (1957) and Yamaguchi *et al.* (1960). Thunberg (1945) determined the citric acid content of several varieties of potatoes over storage periods up to 6 months. Minina (1953) investigated the concentrations of both citric and malic acids during seven months. The relative neglect of this field of investigation may be due to the inconvenience of determining each acid by a different method of analysis. The authors (Schwartz *et al.*, 1961), however, have adapted ion-exchange methods so that a single chromatographic run can determine glutamic, aspartic, pyroglutamic, malic, citric, oxalic, and phosphoric acids. In the present work these acids were determined monthly in three specific-gravity fractions of potatoes stored ten months.

MATERIALS AND METHODS

Maine Katahdin potatoes were stored at 38°F beginning September 25, 1959. Each month a sample was removed and divided into six specific-gravity fractions with salt brines. Two samples each, of the highest, intermediate, and lowest specific-gravity fractions, were selected, peeled, and extracted with 70% ethanol. The samples and extracts used were the same in this and the earlier study (Talley *et al.*, 1961). The earlier paper gives further details on storage, sampling, and extraction methods; it also gives data on weight loss during storage, solids content, and specific gravity of the samples.

To induce sprouting after the initial eight-month storage period, a sample was stored one month at 45°F and then one month at 50°F.

Extracts were analyzed for acids by the above-mentioned method of ion-exchange chromatography (Schwartz *et al.*, 1961; Schwartz, 1960).

RESULTS AND DISCUSSION

Table 1 lists the results. To test the precision of the method, up to four replicate analyses were made on some of the samples. To test the sampling procedure, both samples of a particular specific-gravity fraction were analyzed in some cases. Table 2, which lists the Standard Deviations obtained, indicates that the precision of sampling was adequate when compared to the precision of repeating analyses of a single sample.

The results in Table 1 are not corrected for loss of weight during storage, which was about 0.7% per month. Since Talley *et al.* (1961), Treadway *et al.* (1949), and Schwimmer *et al.* (1954) have reported that the ratio of weights of solid loss to moisture loss remains nearly constant, the relation between acid content and specific gravity should not be affected by loss of moisture. Table 1 shows that, in general, the concentrations of all the acids except citric (calculated on a moisture-free basis) vary inversely as the specific gravity. With citric acid this inverse relationship occurs only in the last half of the storage period. These results confirm what would be expected from Metzger's finding (1956), that starch content increases more sharply than non-starch content as specific gravity increases. When calculated on a fresh-weight basis, the results show no definite relationship between the concentrations of glutamic, aspartic, and oxalic acids and the specific gravity of the potatoes. However, an inverse relationship between specific gravity and acid concentration is shown for pyroglutamic, malic, and phosphoric acids and a strong direct relationship for citric acid and the unidentified acid. Apparently, for a given variety and crop, high-solids potatoes are especially high both in starch and in citric acid, but lower in malic, phosphoric, and pyroglutamic acids. Pyroglutamic acid is probably not present in the fresh potato to the extent calculated, but is derived at least partly from glutamine during extraction or analysis.

Changes in acid content with storage time are shown in Figs. 1 and 2. Changes in the individual fractions followed the same general trends. Although the changes are not great on an absolute basis, they are considerable in relation to the amounts of acid present. It is notable that five of the eight acids determined—glutamic, aspartic, malic, citric, and oxalic acids—show either a maximum or a minimum concentration after one or two months. In addition, pyroglutamic acid, which decreases throughout, shows its sharpest decrease in the first two to three months. The over-all picture is one of an early period of rapid change in acid content, followed by a longer period during which some of the changes are slowly reversed.

Table 1. Relationship of acid content to specific gravity and storage time (moisture-free basis).

Storage time (months)	Glutamic[a]			Aspartic[a]			Pyroglutamic[a]			Malic[a]			Citric[a]			Phosphoric[a]			Oxalic[a]			Unidentified[b]		
	H[c]	I[c]	L[c]	H	I	L	H	I	L	H	I	L	H	I	L	H	I	L	H	I	L	H	I	L
0	....[d]	.32	.30	....[d]	.15	.23	.80	.66	1.22	.47	.54	.38	2.07	2.22	2.02	.19	.25	.27	.09	.10	.14	7.2	7.2	7.8
1	.32	.36	.47	.25	.16	.18	.37	.45	.74	.62	.42	.89	2.13	1.79	2.06	.24	.25	.38	.12	.12	.18	8.1	7.4	9.3
2	.49	.49	.56	.63	.27	.41	.44	.61	.82	.38	.76	.84	1.93	2.16	1.59	.35	.33	.37	.17	.18	.17	8.3	9.3	8.6
3	.36	.44	.41	.39	.41	.51	.22	.26	.36	.44	.52	.71	1.91	1.97	2.15	.25	.29	.42	.13	.16	15	8.5	8.6	9.8
4	.41	.41	.52	.37	.26	.37	.72	.28	.31	.40	.44	.54	1.94	1.69	2.25	.35	.40	.48	.13	.14	.08	8.3	7.2	....
5	.41	.39	.32	.27	.38	.45	.20	.24	.31	.47	.42	.59	2.01	1.93	2.15	.25	.26	.27	.12	.12	.13	8.7	8.1	8.6
6	.37	.40	.49	.33	.40	.37	.24	.31	.43	.35	.43	.52	2.12	2.15	2.22	.26	.30	.39	.12	.14	.17	8.2	9.1	9.8
7	.35	.35	.38	.29	.34	.43	.18	.21	.30	.32	.33	.45	2.00	2.08	2.19	.21	.23	.32	.07	.12	.14	10.3	9.0	8.9
8	.38	.43	.48	.31	.35	.42	.15	.20	.21	.35	.35	.41	2.19	2.38	2.37	.25	.25	.31	.14	.15	.15	9.2	8.7	8.2
9	.39	.42	.51	.39	.40	.47	.29	.34	.54	.33	.37	.44	2.22	2.25	2.57	.25	.29	.38	.14	.16	.18	9.0	9.2	10.1
10	.36	.40	.46	.38	.41	.50	.23	.26	.21	.37	.37	.43	2.36	2.34	2.24	.23	.30	.38	.14	.15	.20	9.0	9.1	9.9
10[e]		.24			.15			.08			.13			.61			.93			.30			9.6	

[a] Per cent weight. [b] Milliequivalents %. [c] H, I, and L respectively stand for fractions of high, intermediate, and low specific gravity. [d] No acid peak appeared. [e] Sprouts.

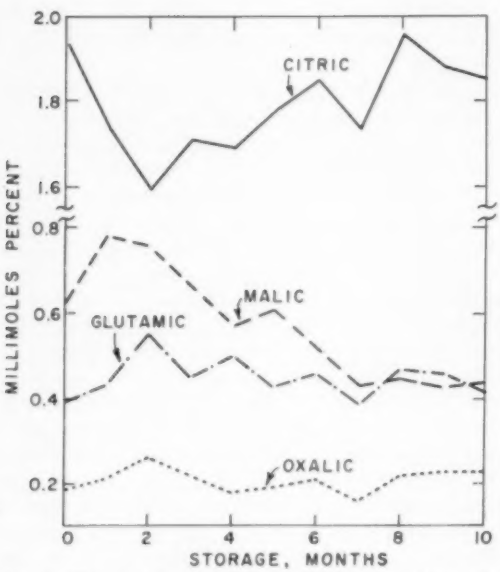

Fig. 1. Change in acid content with storage time (fresh-weight basis). Eight months at 38°F followed by one month at 45°F and one month at 50°F. Averages of three specific-gravity fractions corrected for loss of weight during storage.

The results of Minina's study (1953) of changes in citric and malic acid content were similar in that they included an initial decrease in citric acid content followed by an increase, a decrease in malic acid toward the end of the period, and a preponderance of citric over malic acid at all stages. The increase in citric acid between the second and eighth months of storage (Fig. 1) is equal to the initial decrease, and to the decrease in malic acid occurring at the same time. This shows a possible conversion of malic to citric acid; such conversions have been reported (Krotkov and Barker, 1948; Pucher and Vickery, 1949).

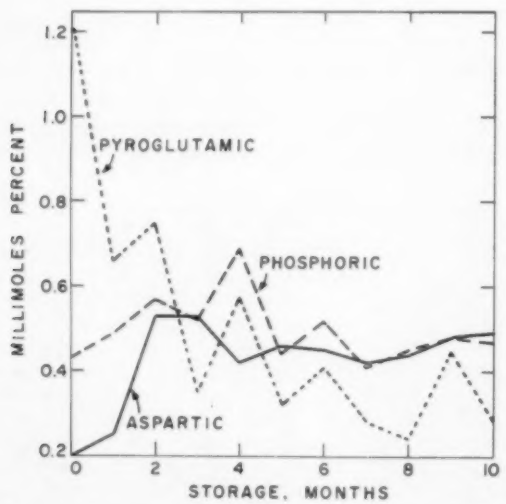

Fig. 2. Change in acid content with storage time (fresh-weight basis). See caption for Fig. 1.

Table 2. Precision of replication and sampling.

Acid	Replicate analyses		Replicate samples	
	Standard deviation	Degrees of freedom	Standard deviation	Degrees of freedom
Glutamic	.04	11	.02	7
Aspartic	.10	10	.05	7
Pyroglutamic	.06	11	.05	7
Malic	.05	11	.01	7
Citric	.06	11	.04	7
Phosphoric	.02	11	.03	7
Oxalic	.02	11	.01	5
Unidentified	.47	11	.26	6

The final two months of storage (higher temperatures) produced no significant changes in acid content of the tubers. However, the resulting sprouts had a strikingly different pattern of acid concentrations. Most of the acids were present in smaller amounts, but the concentrations of phosphoric and oxalic acids were greatly increased.

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Effect of Room Temperature vs. Refrigerated Storage on Quality of Canned Fruit and Vegetable Products

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(Manuscript received November 3, 1960)

SUMMARY

Twenty-six commercially canned fruit and vegetable products were stored at 75–80°F and at 34–36°F to study color and flavor changes during normal and refrigerated storage and to demonstrate subjective changes that may accompany reported nutritive losses. All products displayed some color and/or flavor changes at the higher storage temperatures; changes were generally significantly slowed by the lower temperatures. Changes observed at 75–80°F storage were very marked quality loss in 10 products: 6 fruit drinks, 2 fruit-pie fillings, 1 fruit, and 1 vegetable product. Four products showed moderate change at 75–80°F; 8 displayed slight changes; and 1 was benefited by higher temperature. Differential between rate of chemical reactions at 75–80°F versus 34–36°F determines the amount of benefit obtained from refrigerated storage of these canned foods.

CANNED FOODS undergo significant biochemical changes during normal and ambient-temperature storage. These changes include losses in nutritive value (Brenner *et al.*, 1948; Clifcorn, 1948; Feaster *et al.*, 1946; Guerrant *et al.*, 1948; Moschette *et al.*, 1947; Sheft *et al.*, 1949), alterations in biochemical constituents responsible for subjective factors (Tressler *et al.*, 1955), and subjective quality losses (Brody and Bedrosian, 1959; Feaster *et al.*, 1946; Guyer and Boyd, 1954; Huggart *et al.*, 1955; Moyls *et al.*, 1955; Tressler *et al.*, 1955; Whittenberger and Hills, 1956). Although many more papers describing this phenomenon in terms of vitamin loss were found in the scientific literature, no references other than those listed were found demonstrating subjective changes that occur simultaneously. Since the ultimate consumer test of any food product is what he or she senses in the mouth, nose or eyes, subjective impression is a very important factor in canned food quality. Paucity of reference data on subjective changes in canned foods during storage stimulated interest in various canned fruit and vegetable products believed to be subject to these changes. Low-temperature storage to retard these changes was also investigated.

EXPERIMENTAL PROCEDURES

Twenty-six products in 6 categories (fruit drinks, fruit, fruit-pie fillings, mushroom products, vegetables, and baby foods) were received within 48 hours of canning and stored under two temperature conditions: 75–80°F, which approximates normal commercial storage (Monroe *et al.*, 1949), and 34–36°F, a good refrigerated temperature at which the products would not be subject to freezing. At intervals sample cans were removed from each storage condition and evaluated for appropriate subjective and biochemical factors. Hereinafter the storage treatments are referred to as HT (high temperature) and LT (low temperature).

Trained taste panels of 5–10 persons, using paired comparison tests and hedonic scoring scale, made the subjective evaluations. Since these were small, select panels, their preference data could not necessarily be considered valid; any preference data presented would be considered merely indicative of further investigation with larger consumer-type panels. Samples were either served after equilibration to 50°F or after reheating in boiling water bath, depending upon whether product is normally consumed warm or cold.

Objective color data were obtained by tristimulus reflectance readings from a Hunter Color and Color Difference Meter (Gardner Laboratories, Bethesda, Maryland) with standard ceramic plates as references. In some products reduced ascorbic acid content was determined by visual titration or by indophenol-xylene extraction (Assoc. of Vitamin Chemists, 1951).

RESULTS

For brevity, data from some products are not tabulated or graphed, but are summarized below.

Fruit drinks. No. 3 cans of apple juice blended from Jonathan, Grimes, McIntosh, and Delicious varieties and having an initial 10.5° Brix were evaluated. Taste-panel results indicated highly significant preferences for LT over HT samples after only 1 month. Loss of characteristic apple aroma was noted in HT samples, which had a sweet-tart flavor during storage, as compared with the full-bodied apple flavor of LT samples. Transmission colorimetry indicated a progressive and slow darkening of LT juice, but an almost immediate darkening of HT juice.

Pineapple-grapefruit drink in No. 3 cans showed over 10% loss of its original ascorbic acid after 6 months at HT, as opposed to no losses in LT samples. Preference was significant for LT samples after 2 months.

Fig. 1 shows losses of reduced ascorbic acid in strained pineapple-grapefruit drink, indicating losses as high as 25.8% in HT samples in 10 months, as opposed to no significant losses in LT product.

Two lots of pineapple-orange drink in No. 3 cans were separately evaluated. Losses of reduced ascorbic acid as high as 30% were shown in 11 months at HT; LT samples showed no significant losses in this period (Fig. 2). Color darkening of HT samples was noted at 1 month and thereafter; LT samples displayed no color changes. Preference for LT samples was significant at 1 month, and became more pronounced as storage period increased.

Pineapple-pear drink in 307 × 700 cans displayed 31% losses in reduced ascorbic acid content in 10 months at HT as opposed to no losses at LT (Fig. 3). At 2 months' storage and thereafter (to 10 months), LT samples were preferred.

Orange-apricot drink in 307 × 700 cans lost 36% of its initial reduced ascorbic acid content in 10 months at HT; LT samples lost less than 7% (Fig. 4). LT samples were preferred, from 1 month on (to 10 months).

Tomato juice in No. 3 cans at 75–80°F was significantly preferred at HT over LT during all 12 months. Thus, the results are the reverse from those for other products. Although nu-

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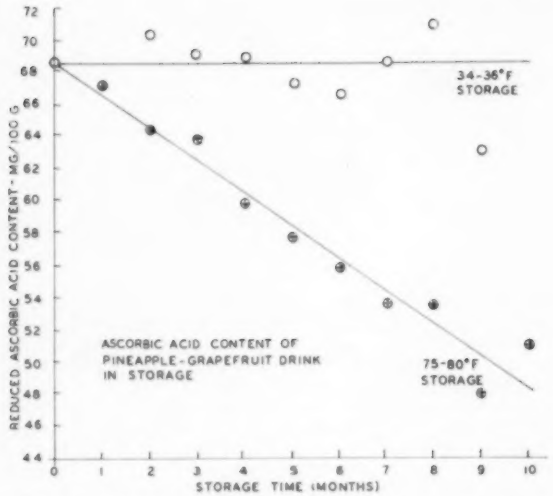
REDUCED ASCORBIC ACID CONTENT - MG/100 G
STORAGE TIME (MONTHS)
34-36°F STORAGE
75-80°F STORAGE
ASCORBIC ACID CONTENT OF PINEAPPLE-GRAPEFRUIT DRINK IN STORAGE

Fig. 1. Reduced ascorbic acid content of canned strained pineapple-grapefruit juice in storage 10 months at 34–36 and 75–80°F.

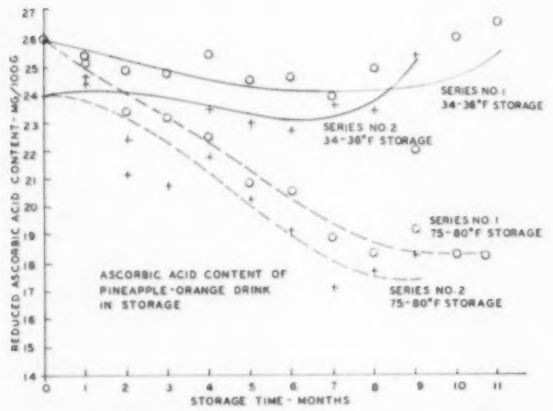
REDUCED ASCORBIC ACID CONTENT - MG/100G
STORAGE TIME - MONTHS
SERIES NO. 1 34-36°F STORAGE
SERIES NO. 2 34-36°F STORAGE
SERIES NO. 1 75-80°F STORAGE
SERIES NO. 2 75-80°F STORAGE
ASCORBIC ACID CONTENT OF PINEAPPLE-ORANGE DRINK IN STORAGE

Fig. 2. Reduced ascorbic acid content of canned pineapple-orange drink in storage 11 months at 34–36 and 75–80°F.

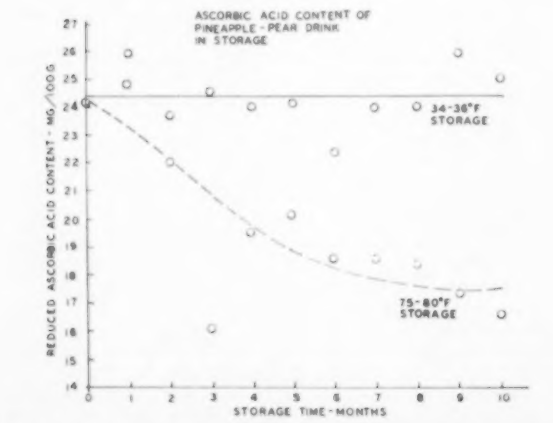
ASCORBIC ACID CONTENT OF PINEAPPLE - PEAR DRINK IN STORAGE
REDUCED ASCORBIC ACID CONTENT - MG/100G
STORAGE TIME - MONTHS
34-36°F STORAGE
75-80°F STORAGE

Fig. 3. Reduced ascorbic acid content of canned pineapple-pear drink in storage 10 months at 34–36 and 75–80°F.

Table 1. Color and taste-panel scores: canned sweet cherries in storage.

Storage time (months)	Gardner colorimeter "a" values (Higher "a" value = increasing red hue) 34–36°F	75–80°F	Av. hedonic rating[a] 34–36°F	75–80°F
0	+11.7		8.0	
1			8.0	7.4
2	+13.0	+10.7		
3			7.4	6.6
6	+ 9.3	+ 7.6	8.5	7.4*
9	+ 7.9	+ 5.8	8.2	7.0*

* Difference significant at 5% level.
[a] Nine-point scale.

tritive retention is better at LT (Moschette *et al.*, 1947; Sheft *et al.*, 1949), flavor is improved for the consumer by biochemical reactions and tin salt dissolution at HT. Tomato juice packed in 32-oz jars and held at LT was preferred to similarly packed HT samples, thus lending credence to the belief that can lining enhances the flavor of tomato juice.

Fruit. Two separate lots of red sour pitted cherries (Montmorency var.) water-packed in No. 303 cans displayed highly significant color losses in only 1 month at HT. These losses, not found in LT samples, increased through the 12-month storage period (Fig. 5). LT samples scored significantly higher than HT for all 9 months.

As to sweet cherries (Schmidt var.) packed in sirup in No. 300 cans, LT samples were preferred over HT during all 9 months. Colorimetric "a" values showed a more rapid loss of red color in HT samples than LT samples (Table 1).

LT storage of Amber Gem (clingstone) peach halves packed in sirup in No. 2½ cans resulted in slight preference over HT samples after 10 months. With Elberta peach halves in No. 2½ cans, LT was significantly preferred over HT at 3 months and thereafter (12 months).

Sirup-packed Bartlett pear halves in No. 303 cans at LT were preferred at 6 months and thereafter (12 months). Reflectance readings of Bartlett pears were significantly higher for LT than for HT at 2 months, with progressively increasing differential up to 12 months. This indicated a progressive darkening of color, a factor confirmed by consistently lower "b," or yellow hue, reading for LT samples.

Kiefer pear halves similarly packed and stored at HT also showed significant darkening at 2 months and thereafter (12 months).

Fruit-pie fillings. Commercially canned cherry-pie filling in No. 2 cans was significantly preferred at three months and thereafter when given LT storage (Table 2). Color loss was noted by "a" value readings after only 1 month at HT, with darkening increasing throughout (12 months). At LT, color was retained well.

Commercially canned apple-pie filling in No. 2 cans stored at LT was preferred at 1 month and thereafter (12 months). Significant color darkening in HT samples, noted by reflectance

Table 2. Color and taste-panel scores: canned cherry-pie filling in storage.

Storage time (months)	Gardner colorimeter "a" values (Higher "a" value = increasing red hue) 34–36°F	75–80°F	Av. hedonic rating[a] 34–36°F	75–80°F
0	+30.6		8.0	
1	+28.4	+24.2		
2	+25.3	+20.7		
3	+26.3	+19.8	8.0	7.0*
4	+27.4	+19.1	8.0	6.5*
5	+29.8	+20.3	8.0	6.5*
6	+28.9	+18.1	8.5	6.5*
7	+23.8	+18.8	7.6	7.3
8	+27.4	+17.4		
9	+27.4	+19.2	8.2	7.0*

* Difference significant at 5% level.
[a] Nine-point scale.

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Comparison of weight loss for coated vs. uncoated frozen whiting

Conditions: dip bath temp. 160°C. (320°F.)
storage temp. −17°C. ±3°C.
dip time 1 second

sample	type of coating	fish temp. °C.	% coating	% weight loss, weeks 1	2	3	4	5	6
1	control	−20°C. (−4°F.)	—	3.0	4.3	6.0	8.1	9.6	11.2
2	ice glaze	−20°C. (−4°F.)	4.65	3.6	6.1	7.7	9.9	11.4	13.3
3	MYVACET	−20°C. (−4°F.)	4.38	0.3	0.3	0.4	1.0	1.1	1.3

Then, when the whole fish is cut, another dip re-coats the exposed surfaces equally quickly and easily. With weight loss still no problem, there's little need to add expensive compensating overages at this stage.

When the fish gets to the supermarket, the tight-clinging film coat is still working for you, preventing unappetizing freezer burn which might discourage the lady shopper. In fact, the looks of the finished product can be so improved that you may even spend less for package design, both protective and ornamental.

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Let us go into more detail on the whole matter by means of a technical bulletin which fully describes the application of *Myvacet* distilled acetylated monoglycerides to frozen fish. Let us also send you samples of the types suited to your business. The address is ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York and Chicago • W. M. Gillies, Inc., West Coast • Charles Albert Smith Limited, Montreal and Toronto.

*We mean just that. *Myvacet* distilled acetylated monoglycerides are treated by the body as true foods, and approved for use up to 5% for various purposes in or on finished food. See U. S. Food and Drug Regulations, Sec. 121.1018. The quantity applied in coating fish is on the order of 2 to 5%.

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Table 3. Color and taste-panel scores: canned apple-pie filling in storage.

Storage time (months)	Gardner colorimeter R_d values (Lower R_d value = darker) 34–36°F	75–80°F	Av. hedonic rating[a] 34–36°F	75–80°F
0	19.9		7.4	
1	19.0	19.1	7.9	7.7
2	19.2	21.3	7.9	7.3
3	20.2	18.1	7.5	5.7*
4	19.8	17.8	7.5	6.0*
6	22.2	19.0	7.7	6.5*
9	18.6	14.7	7.8	7.2
11	18.0	17.0	7.8	5.8*
12	19.5	16.8	8.0	6.2*

* Difference significant at 5% level.
[a] Nine-point level.

readings at 2 months, increased throughout storage (Table 3).

Commercially packed blueberry-pie filling in No. 2 cans stored at LT was preferred at 1 month and thereafter (9 months). Colorimeter readings showed a slightly more blue hue in LT samples than HT at 2 months and thereafter (9 months).

No significant storage changes or differences were noted in raisin-pie filling.

Mushrooms. Colorimetric readings of both brine and slurried solids of whole mushrooms (2½-oz cans), button mushrooms (4-oz cans), sliced whole mushrooms (2½-oz jars), and mushroom stems and pieces (2-oz cans) showed that LT samples had higher yellow-green readings than HT samples throughout 7 months. Similarly, reflectance readings of HT samples were lower throughout storage, indicating darker color. Although small but colorimetrically significant color differences existed between HT and LT samples, with LT samples showing less change, no significant taste differences were observed.

Colorimetrically, condensed cream of mushroom soup in 10½-oz cans had higher reflectance and lower yellow and red readings at LT than at HT throughout 10 months. Thus, HT samples were darker than LT samples. LT samples had color readings closer to initial readings than did HT samples. However, no significant preferences were detected on reconstituted samples.

Asparagus. Asparagus cuts in No. 300 cans showed no significant flavor differences between HT and LT throughout 12 months. Color, however, was markedly affected. Colorimetric data showed significant yellowing after 5 months at HT, increasing thereafter. Green color was well retained in LT samples.

Pureed vegetables. Colorimeter readings on strained carrots in 4½-oz jars had lower R_d values for HT than LT after only 1 month, increasing thereafter (10 months). Thus, HT samples were darker than LT samples. LT samples also had a more positive "b" value from 1 month on, indicating more desirable yellow color (Table 4).

Strained green beans in 4½-oz jars at LT had higher colorimetric R_d values throughout 7 months, indicating that HT samples were darker. Similarly, LT samples had more negative "a" values throughout storage, indicating more green hue (Table 4). Reduced ascorbic acid content of LT samples remained unchanged, whereas HT samples lost over 18% in storage (Fig. 6). HT and LT showed no consistent taste differences, however.

CONCLUSIONS

Since the products evaluated represent most fruit and vegetable products canned in or near southwestern Michigan, one of the largest fruit and vegetable packing regions in this country, results do not represent particular products selected because of their reactions to their temperature environments.

The results clearly demonstrate that, in general, subjective color and flavor changes accompany nutritive changes. For most of the products studied, color and flavor changes are almost completely retarded in

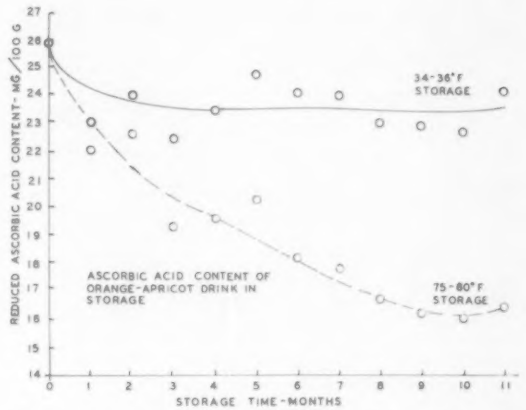
REDUCED ASCORBIC ACID CONTENT - MG/100 G
34-36°F STORAGE
ASCORBIC ACID CONTENT OF ORANGE-APRICOT DRINK IN STORAGE
75-80°F STORAGE
STORAGE TIME-MONTHS

Fig. 4. Reduced ascorbic acid content of orange-apricot drink in storage 11 months at 34–36 and 75–80°F.

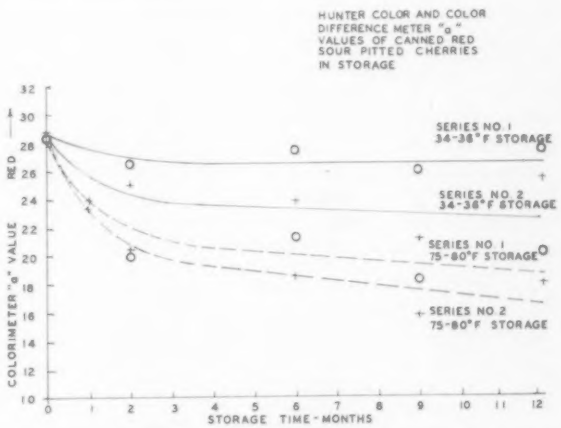
HUNTER COLOR AND COLOR DIFFERENCE METER "a" VALUES OF CANNED RED SOUR PITTED CHERRIES IN STORAGE
COLORIMETER "a" VALUE
SERIES NO. 1 34-36°F STORAGE
SERIES NO. 2 34-36°F STORAGE
SERIES NO. 1 75-80°F STORAGE
SERIES NO. 2 75-80°F STORAGE
STORAGE TIME-MONTHS

Fig. 5. Color of canned red sour pitted cherries in storage at 34–36 and 75–80°F as measured by Hunter color and color-difference meter "a" values. Increasing values of "a" indicate more red color.

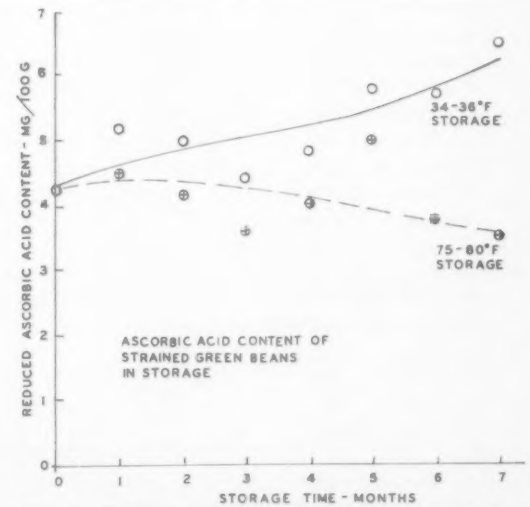
REDUCED ASCORBIC ACID CONTENT - MG/100 G
34-36°F STORAGE
75-80°F STORAGE
ASCORBIC ACID CONTENT OF STRAINED GREEN BEANS IN STORAGE
STORAGE TIME-MONTHS

Fig. 6. Reduced ascorbic acid content of strained green beans stored at 34–36 and 75–80°F.

Table 4. Color and taste-panel scores: pureed vegetables in storage.

Storage time (months)	Strained carrots				Strained green beans			
	Colorimeter R_d (Lower R_d value = darker)		Av. hedonic[a] rating		Colorimeter readings Lower R_d value = darker More negative "a" value = more green hue			
					34–36°F		75–80°F	
	34–36°F	75–80°F	34–36°F	75–80°F	R_d	a	R_d	a
0	15.4		7.6		13.1	−6.3		
1	15.7	15.0	7.7	5.7*	14.1	−3.6	13.4	−3.2
2	16.2	15.6			14.7	−3.2	14.1	−2.9
3	16.5	15.0	7.7	6.3*	14.4	−3.5	13.5	−2.8
4	16.4	15.6	8.3	6.3*	14.5	−3.7	13.8	−3.0
5	16.8	15.2	8.0	6.5*	15.0	−3.6	13.8	−2.9
6					14.9	−3.7	13.9	−3.1
7	17.0	15.2	8.0	6.7*	15.3	−3.7	13.9	−3.0
8	17.6	15.7	8.0	3.0*				
9	16.6	13.7	7.0	4.7*				
10	16.3	14.1	8.0	3.0*				

* Significant at the 5% level.
[a] Nine-point scale.

a year's storage by refrigerated conditions. Previous work has demonstrated that biochemical changes in canned foods can be retarded virtually as effectively at 50°F as at 34–36°F (Brody *et al.*, 1960). Storage at the higher refrigerated temperature would be significantly less expensive to achieve and could lessen problems which may be encountered with sweating and rusting when canned goods are transferred from cold storage into warm, humid atmospheres.

Products investigated may be categorized into 4 groups as to benefits from refrigerated storage:

1) Great benefit
   - Apple juice
   - Pineapple-grapefruit drink
   - Strained pineapple-grapefruit drink
   - Pineapple-orange drink
   - Pineapple-pear drink
   - Orange-apricot drink
   - Tomato juice in jars
   - Red sour pitted cherries
   - Cherry-pie filling
   - Apple-pie filling
   - Asparagus
2) Moderate benefit
   - Sweet cherries
   - Bartlett pears
   - Condensed cream of mushroom soup
   - Strained green beans
3) Slight or no benefit
   - Clingstone peaches
   - Freestone peaches
   - Blueberry-pie filling
   - Raisin-pie filling
   - Whole mushrooms
   - Sliced whole mushrooms
   - Mushroom stems and pieces
   - Strained carrots
4) Adversely affected
   - Tomato juice in cans (for average preference)

Acknowledgments

Thanks are due the product suppliers: Michigan Fruit Canners, Benton Harbor, Michigan; Sodus Fruit Exchange, Sodus, Michigan; Michigan Mushroom Company, Niles, Michigan; California Packing Company, Frankfurt, Illinois; Gerber Products Company, Fremont, Michigan.

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The Effect of Internal Temperature and Time of Cooking on the Palatability of Pork Loin Roasts*

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(Manuscript received January 19, 1961)

SUMMARY

How the palatability of pork loin roasts is affected by different internal temperatures and cooking time was determined on 14 pork carcasses in two trials. There were four treatments of cooking pork loin roasts at 176.6°C: to internal temperatures of 85°C (A); 73.9°C (B); 65.6°C (C); and maintained at 65.6°C for one hour (D). Tenderness scores were reduced as the internal temperature was increased, and slightly increased as time was prolonged. Flavor scores increased as internal temperature was increased. Cooking time, drip loss, evaporation loss, and total loss during cooking increased as internal temperature and cooking time were increased. There were no significant differences in carving losses due to differences in internal temperature or cooking time.

Trichinella spiralis is transferred when contaminated pork is not properly cooked. Early research (AMIF, 1960; Child, 1938; Lowe, 1955; National Live Stock and Meat Board, 1937; Noble and Hardy, 1945; Satorius and Child, 1938; Ziegler, 1958) on the temperature that would destroy *T. spiralis* led to the recommendation that pork be cooked to the well-done state (internal temperatures of 82.2–85.0°C).

Since meat thermometers were not then in general use, high internal temperatures were recommended to assure thorough destruction of *T. spiralis*. Consequently, the color change usually associated with well-done pork (gray) was recommended as an indication that the pork was safe to eat. Consumers have been thoroughly educated that even slightly pink pork is unacceptable. However, it has been shown that not all pork loses its pink even when well-done (AIMF, 1960).

Studies at the Meat Inspection Division, U.S.D.A. (1960), demonstrated that *T. spiralis* was completely destroyed and bacterial contamination reduced sufficiently at 58.3°C. Thus, the currently recommended margin of safety in cooking pork is about 26°C, considerably more than is reasonable. A lower end temperature would possibly yield a pork product that is improved and still safe.

The study reported here was undertaken to determine various temperatures above 58°C but below 83°C that would be palatable and economical for the consumer. This is a preliminary study, and the scores of the laboratory panel will not necessarily match consumer reactions.

EXPERIMENTAL METHODS

Trial I. Four pork loins were each cut into four semi-boned roasts (about 2.5 lb each), wrapped in laminated freezer paper, blast frozen at −28.9°C, and stored one month at −17.8°C. In the cooking trials, the four roasts from each loin were divided into four treatment (internal temperature) groups: A) 85°C, B) 73.9°C, C) 65.6°C, and D) 65.6°C maintained one hour. The treatments were assigned to a Latin-Square design. After thawing for 36 hr at 5.6°C, the roasts were placed in shallow roasting pans, the bone side on the meat roasting rack, and heated to the specified internal temperature in a 176.6°C oven. The roasts for treatment D, immediately on reaching 65.6°C in the 176.6°C oven, were transferred to a separate 65.6 ± 0.5°C oven. Internal temperatures were determined with a recording potentiometer. The roasts from each loin were prepared the same day as specified by random assignments.

A laboratory panel of six trained judges evaluated the cooked meat at about 37°C for flavor, tenderness, and juiciness on a 9-point hedonic scale (9, highest; 1, lowest). A one-inch core, one-half inch long, was taken from the same position of each roast and served to the judges. All samples were tasted in a separate testing room lighted by red fluorescent lights. Cooking times and total evaporation and drip losses during cooking were recorded.

Trial II. Roasts of about 2.5 lb each were taken from ten hogs posterior to the 8th rib of the right and left loins. The roasts were wrapped, frozen, stored, thawed, and prepared for testing as in Trial I except that they were allotted by a randomized design. Tasting was as in Trial I, with ratings for initial tenderness, residual tenderness, juiciness, and flavor on a 9-point hedonic scale (9, highest; 1, lowest). Initial tenderness was defined as the impression of tenderness gained after biting into the meat three times. Residual tenderness was defined as tenderness after the meat is thoroughly masticated and ready for swallowing. Five one-half-inch cores were taken from a one-inch slice of each roast. These slices were adjacent to those used for panel evaluation. Each core was sheared with the Warner-Bratzler shear machine. Total evaporation and drip losses during cook-

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ing, and the cooking times, were recorded as in Trial I. In addition, losses during carving were the reduction in weight caused by the removal of samples for taste-panel and shear determinations.

RESULTS AND DISCUSSION

Tenderness and flavor did not differ significantly for the different roasts, according to panel scores (Table 1). The lack of significant differences in tenderness may have been due to an initial variation in tenderness among the loins used in this trial.

Table 1. Effect of internal doneness temperature on the palatability of pork loin roasts.

Internal doneness temperature[a]	Tenderness	Juiciness	Flavor
85.0 (A)	5.4 ± .49	4.6 ± .78	6.8 ± .22
73.9 (B)	5.4 ± .41	5.8 ± .12	6.8 ± .19
65.6 (C)	5.8 ± .81	6.6 ± .81	6.2 ± .36
65.6 (D)	5.8 ± .39 (C,D,A,B)[b]	6.2 ± .43 (C,D,B) (D,B,A)	6.6 ± .30 (A,B,D,C)

[a] The abbreviations used in this paper are as follows: A = Internal doneness temperature 85°C; B = Internal doneness temperature 73.9°C; C = Internal doneness temperature 65.6°C; and D = Internal doneness temperature 65.6°C and maintained for one hour.

[b] The tests of significance are presented so that any two means included by the same parentheses are not significantly different; any two means not included by the same parentheses are significantly different ($P < .05$). The standard error of the mean is shown following each treatment mean.

Juiciness scores (Table 1) were significantly higher for the roasts cooked to 65.6°C than for those cooked to 85°C, but there was no significant difference between the other treatments.

The losses during cooking increased as time and internal temperature increased (Table 2). Cooking losses were inversely related to juiciness ratings, which suggests that juiciness is a function of cooking loss. The increase in flavor ratings as the internal temperature was increased suggests that the cooked meat flavor is a function of various tissue components being combined and concentrated as time and temperature of cooking are increased. Perhaps the panel members had been conditioned to prefer the flavor that develops in pork cooked to an internal temperature of 85°C. Conversely, juiciness ratings decreased when cooking time and internal temperature were increased, which indicated that muscle fiber and moisture changes during cooking reduced panel ratings for this attribute.

Table 2. Effect of internal doneness temperature on the cooking time and component losses of pork loin roasts.

Internal doneness temperature[a]	Cooking time	Drip loss	Evaporation loss	Total cooking loss
°C	Min	%	%	%
85.0 (A)	152.5 ± 7.2	8.30 ± 0.68	21.47 ± 0.63	29.78 ± 1.08
73.9 (B)	118.0 ± 12.8	6.52 ± 1.16	16.60 ± 1.47	23.13 ± 2.49
65.6 (C)	102.0 ± 10.8	4.64 ± 0.98	10.36 ± 1.06	15.00 ± 1.45
65.6 (D)	160.0 ± 3.5 (D,A,B,C)[b]	5.25 ± 0.98 (A)(B,D) (D,C)	14.73 ± 1.51 (A)(B,D) (C)	19.98 ± 1.40 (A)(B)(D) (C)

[a] See abbreviations for Table 1.

[b] See abbreviations for Table 1.

The results of Trial II are presented in Tables 3, 4, and 5. Initial and residual tenderness scores (Table 3) showed a similar trend toward increased tenderness as the internal temperature of doneness was decreased. Shear values were significantly higher for treatment B (Table 3) than for treatment D, with no significant difference between other treatments. The means indicate that the roasts cooked at higher internal temperatures (treatments A and B) are less tender than those cooked at lower internal temperatures (treatments C and D). The means for all of the criteria of tenderness evaluation suggest that there was a pronounced reduction in tenderness between 65.6°C and 73.9°C. These results verified the slightly higher tenderness means for lower internal temperature of Trial I (Table 1). This decrease in tenderness did not appear to be related to an increased time of cooking at a constant internal temperature, because treatment D indicated a slight tenderization action when compared with Treatment C. It seems apparent that the increase in internal temperature changed muscle proteins to reduce tenderness, but this effect was not observed for an extended holding time at a constant temperature.

Table 3. Effect of internal doneness temperature on the tenderness of pork loin roasts.

Internal doneness temperature[a]	Initial tenderness	Residual tenderness	Warner-Bratzler shear values
°C			
85.0 (A)	5.6 ± .32	5.3 ± .34	7.6 ± .69
73.9 (B)	5.8 ± .31	5.6 ± .30	7.7 ± .56
65.6 (C)	6.3 ± .38	6.0 ± .42	7.0 ± .50
65.6 (D)	6.8 ± .36 (D)(C,B)(B,A)[b]	6.4 ± .28 (D,C)(C,B) (B,A)	6.9 ± .50 (A,B,C)(A,C,D)

[a] The abbreviations used in this paper are as follows: A = internal doneness temperature 85°C; B = internal doneness temperature 73.9°C; C = internal doneness temperature 65.6°C; and D = internal doneness temperature 65.6°C maintained for one hour.

[b] The tests of significance are presented so that any two means included by the same parentheses are not significantly different; any two means not included by the same parentheses are significantly different ($P < .05$). The standard error of the mean is shown following each treatment mean.

Juiciness scores (Table 4) tended to increase as temperature was lowered. These results parallel those in Table 1.

The treatment means indicated that flavor scores increased as internal temperature was increased. Treatment A was significantly higher in flavor ratings

Table 4. Effect of internal doneness temperature on juiciness, flavor and cooking time of pork loin roasts.

Internal doneness temperature[a]	Juiciness	Flavor	Cooking time
°C			Min
85.0 (A)	3.9 ± .44	6.2 ± .17	115.9 ± 3.41
73.9 (B)	5.9 ± .40	5.5 ± .18	80.4 ± 3.46
65.6 (C)	7.0 ± .24	5.6 ± .15	70.4 ± 3.72
65.6 (D)	7.0 ± .22 (C,D)(B)(A)[b]	5.4 ± .28 (A)(C,B,D)	132.6 ± 4.27 (A)(D)(B,C)

[a] See abbreviations for Table 3.

[b] See abbreviations for Table 3.

than the other treatments. The trends of the data for cooking times are similar in Tables 2 and 4.

Differences in drip, evaporation, and total cooking losses were significant for the treatments (Table 5).

Table 5. Effect of internal doneness temperature on the component losses of pork loin.

Internal doneness temperature[a]	Drip loss	Evaporation loss	Carving loss	Total cooking loss
°C	%	%	%	%
85.0 (A)	9.7 ± .56	18.8 ± .69	3.9 ± .25	28.5 ± .84
73.9 (B)	7.2 ± .28	11.4 ± .72	4.6 ± .55	18.6 ± .84
65.6 (C)	5.3 ± .37	8.2 ± .52	4.4 ± .58	13.5 ± .72
65.6 (D)	5.8 ± .42	10.4 ± .20	3.1 ± .37	16.3 ± .48
	(A)(B) (C,D)[b]	(A)(B,D) (C)	(B,C,A,D)	(A)(B)(D) (C)

[a] See abbreviations for Table 3.

[b] See abbreviations for Table 3.

In general, as cooking time and internal temperature increased, losses increased. Total cooking losses were significantly different for all internal temperatures, with a significant increase as time and temperature were increased. There were no significant differences in carving losses.

The investigation indicated that tenderness and juiciness improved as degree of doneness was reduced. Since an internal temperature of 85°C has been recommended for cooking pork, it seems apparent that the panel members had been conditioned to prefer the flavor that is developed at this higher degree of doneness. The study clearly demonstrated that the lower degrees of doneness permit savings in reduced cooking time and cooking losses.

An internal temperature of 58.3°C allows a 3.8°C safety margin for the destruction of *T. spiralis* (USDA, 1960). However, since many meat thermometers are not extremely precise and some error may result from a failure to center the thermometer, these investigators recommend an internal temperature of 65.0°C as a minimum. This minimum temperature is approximately that currently recommended for cooking rare beef (Lowe, 1955).

Teaching the public that pork is safe to eat if it reaches an internal temperature of 65.0°C, even though it is still pink, will require time and extensive consumer education. Since there was very little difference in flavor scores, it is possible that consumers would prefer roasts cooked to temperatures below 85°C. The consumer can choose a degree of doneness that her family prefers, just as she does for beef. The higher flavor scores for the roasts cooked to higher internal temperatures may be due to a developmental response to the well-done pork roast. Therefore, a desire for the flavor of pork cooked to internal temperatures lower than 85°C may be developed once the consumer has become accustomed to less-well-done pork.

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Maple Sirup. XVIII.

Bacterial Growth in Maple Sap Collected with Plastic Tubing

(Manuscript received April 10, 1961)

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SUMMARY

Study was made of the growth of normal, adventitious microflora of maple sap during collection with transparent plastic tubing by methods currently used. Early in the season an aerial system yielded sap higher in bacterial counts than did a ground system, which counts may have contributed to premature stoppage of sap flow. A build-up of pockets of infection, resulting from the coils of tubing used to anchor suspended tubing lines, seems to contribute to the build-up of bacterial population in the aerial collection system. In the ground system, taphole vents contributed to a more rapid infection than did unvented tapholes.

LARGE systems of interconnected plastic-tubing lines to collect and transport maple sap from taphole to collection tank or storage tank, are replacing less efficient methods used for several generations (Frank and Willits, 1960; Laing *et al.*, 1960; Morrow, 1958). These systems eliminate much of the cost and labor of collection with buckets, and have two additional advantages. First, extraneous matter (leaves, twigs, or insects) is kept from getting into the sap. Second, the polyvinyl tubing used is sufficiently transparent to the ultraviolet radiation in sunlight to permit germicidal action on organisms present in the sap (Frank and Willits, 1960). Nevertheless, new problems arise.

One of the chief difficulties of plastic-tubing systems is mechanical interference with sap flow from "vapor locks" that form in the lines. "Vapor locks" are static pockets of gas liberated from the taphole during sap flow or of air drawn into the system. Unless these pockets are eliminated, sap flow may be greatly reduced or even stopped completely.

Another, and more important, problem is microbial growth in the sap within the tapholes and in the tubing. Microbial populations, especially the psychrophilic bacteria, frequently increase to high levels between sap flows, when static bodies of sap remain in the system (Edson *et al.*, 1912; Frank and Willits, 1960; Naghski and Willits, 1953, 1955; Sheneman and Costilow, 1959; Sheneman *et al.*, 1959). These reservoirs of infection can contaminate the entire system.

Maple sap is sterile when it issues from a freshly made taphole (Edson, 1910; Willits, 1958). As the sap-collection season progresses, the microbial population increases in the taphole tissue and in the sap (Edson, 1910; Hayward and Pederson, 1946; Holgate, 1950; Sheneman and Costilow, 1959; Willits, 1958). The early microflora of sap is composed largely of bacteria, predominantly gram-negative psychrophilic rods (Edson, 1910; Edson *et al.*, 1912; Hayward and Pederson, 1946; Sheneman and Costilow, 1959). Later, yeasts, and then molds, are present in appreciable numbers. The deleterious effects of excessive microbial growth in maple sap on the color and flavor of maple sirup has been reported by many investigators (Edson, 1910; Edson *et al.*, 1912; Hayward and Pederson, 1946; Holgate, 1950; Hucker and Pederson, 1942; Naghski *et al.*, 1957; Willits, 1958). In addition, excessive microbial growth in the taphole tissue can cause premature stoppage of sap flow (Naghski and Willits, 1953; Sheneman *et al.*, 1959), reducing the sap crop. When microbial growth does occur, considerable debris (organic matter) is deposited on the inner surface of the tubing and on spouts and other fittings. Disinfection of contaminated surfaces and removal of debris is laborious but necessary (Willits *et al.*, 1959).

At present, two types of plastic-tubing installations are being used for collecting and transporting maple sap: an aerial and a ground system.

The aerial system consists of suspended plastic-tubing lines connecting, in series, a large number of tapholes on several trees (often as many as fifty). Sap from the most remote taphole passes successively through all spouts in the series before leaving the exit line. To maintain tension the tubing is anchored to a groove in the spout, using a coil arrangement. Sap in this coil does not drain easily, and may serve as a static harbor of infection for subsequent sap runs.

In the ground system the plastic-tubing installation consists of vertical pieces of tubing connecting the taphole spout to a conduit on the ground. Sap does not flow from one taphole through another, as in the aerial system.

A study was made of the growth of the normal, adventitious microflora of maple sap that collects in transparent plastic-tubing lines with the methods currently used by many maple-sirup producers.

METHODS

Observations were made during the 1959 and 1960 maple sap seasons at a sugar bush near Ambler, Pennsylvania. The trees were tapped with an aseptic technique described previously (Naghski and Willits, 1955), and then flushed with a hypochlorite disinfectant diluted to 5000 ppm available chlorine. Washed and disinfected plastic fittings and tubing (Willits *et al.*, 1959) were installed to plan.

In 1959, parallel aerial and ground systems of eight tapholes each were installed on five trees. Neither line was vented. Samples were collected from the effluent sap whenever a sap run occurred. Microbial populations were estimated by diluting the sample and plating with tryptone-glucose-yeast extract agar. Colonies were counted after incubation for about 40 hr at 81°F, a period too short for colony development of yeasts

* Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

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and molds encountered in sap. We therefore assume that the counts represent bacterial populations only.

All the subsequent obesrvations were in 1960. The plastic-tubing systems were installed as described except for the modifications given below. Aliquots of sap, suitable for estimating bacterial counts, were obtained from the sampling apparatus installed adjacent to each taphole (Fig. 1). Samples were obtained by first removing the protective test tube and then opening the clamp to allow the sap to drip freely from the open tube for several minutes. A sterile test tube was attached, and the sap sample collected. This tube was removed, and the protective test tube reinstalled. Bacterial populations in the sap samples were estimated as described above.

The aerial system consisted of 2 tapholes per tree on a row of 5 trees. Tapholes were drilled at gradually decreasing heights to facilitate gravitational flow of sap in one direction. Taphole heights ranged from about 7 feet, on the first tree (I), to about 3.5 ft, on the fifth tree (V). A vent consisting of a 3-ft piece of tubing was connected to the highest taphole on tree I and suspended vertically upward. Samplers (Fig. 1) were installed at each spout so that sap could be collected as it issued from the taphole. The tubing between the trees was kept taut by anchoring a coiled portion of the tubing through a groove in the taphole spout. The tubing was also supported by metal wire lines suspended between the trees to help keep sags at a minimum.

In the ground system, installed on a row of 6 trees on a gradual slope, all tapholes were made at breast height.

Two trees were used to study the microbial population in sap collected with multiple tapholes. Each tree had 3 tapholes, connected in series by 2 short pieces of plastic tubing, emptying into a single effluent line connected to the collection conduit line. The sampler on each tree was installed just below the taphole connected to the effluent line. Thus, sap samples were composites of sap output of all tapholes on each tree. One tree had no venting system. The other tree was vented by a 3-ft piece of tubing connected to the topmost taphole and extending vertically upward.

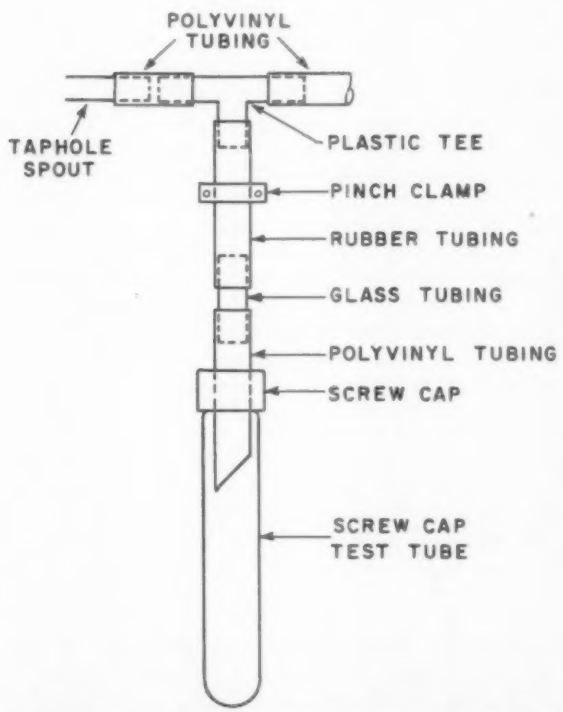

Fig. 1. Apparatus for sampling sap collected with plastic tubing.

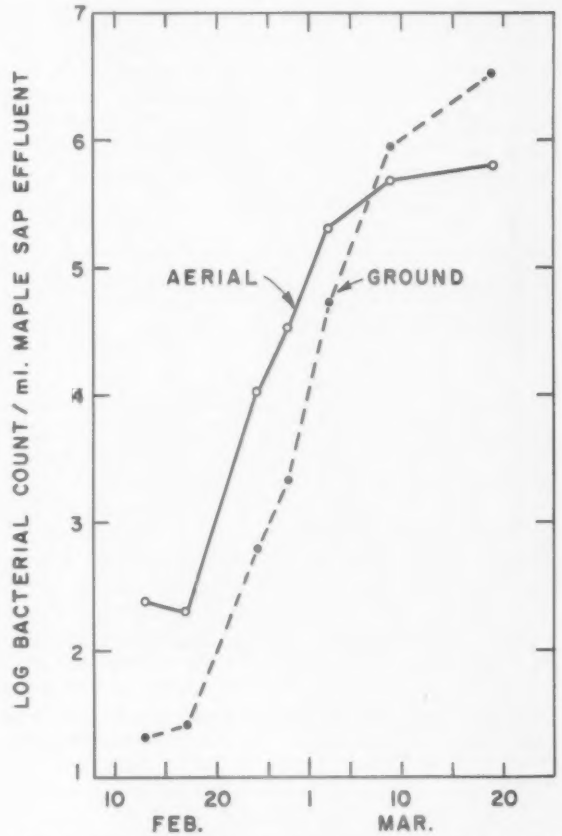

Fig. 2. Comparison of bacterial populations in effluent maple sap from ground and aerial plastic-tubing collection systems.

The 9 tapholes on the 4 remaining trees were connected by individual lines to the collection conduit line. Of these, 5 were equipped with vent lines and 4 were not. All 9 tapholes were installed with samplers for collection of sap.

When sap did not flow from a taphole while other tapholes yielded sap, the stoppage was considered to have resulted from excessive microbial growth (Naghski and Willits, 1953; Sheneman *et al.*, 1959).

RESULTS

Preliminary observations in 1958 had indicated that microbial growth had taken place in experimental aerial and ground sap-collection systems. Since these systems were being used primarily for a study of their mechanical function in sap collection, no estimates were made of microbial populations in the sap. However, considerable microbial debris was found occluded to the plastic fittings and one the inner surfaces of the tubing. Sap samples collected late in the season contained several million organisms per milliliter.

The 1959 systems were installed on January 14. The first collection was on February 13 (Fig. 2). During the earlier runs, microbial populations were slightly higher in sap collected by the aerial system (Fig. 2). As the weather became warmer, the difference between the sap in both systems narrowed, and in fact became reversed on the last two runs.

All subsequent data in this paper are from observations made in 1960. Trees were tapped and tubing installed on February 2, 1960.

Fig. 3 shows the bacterial counts in sap collected from the 5 trees installed with the aerial system of plastic tubing. It is apparent that samples collected from tapholes progressively further "downstream" show increasing bacterial counts. Tree

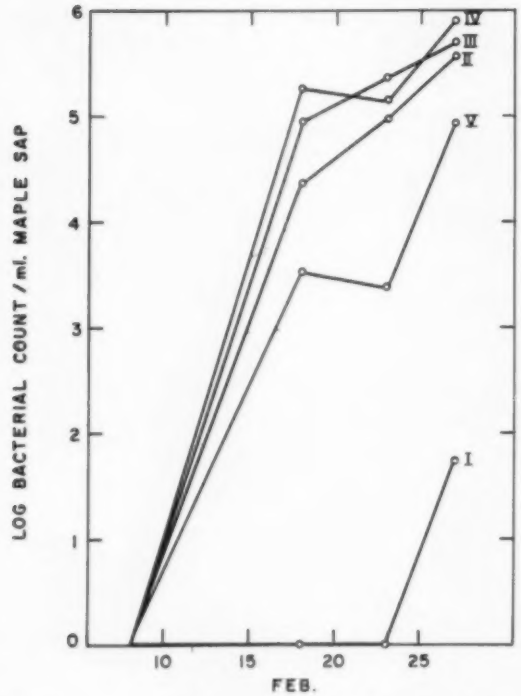

Fig. 3. Comparison of bacterial populations in maple sap from the five tapholes of the aerial plastic-tubing collection system (taphole I being the first, and taphole V the last, in the series).

V, on the other hand, does not fall in line with the trend exhibited by the data observed with trees I through IV, because no coiling of the tubing was used on tree V. The significance of this difference in anchoring is covered in the Discussion.

Fig. 4 shows the effect of venting on a ground-system installation composed of multiple tapholes connected in series on individual trees. Venting apparently permits earlier contamination of the system, leading to a higher bacterial count than in similar but unvented ground systems. As the weather becomes warmer the discrepancy between the two systems decreases and the microbial counts become more nearly equal.

The effect of venting on individual tapholes is best seen in Fig. 5, which demonstrates that bacterial counts rose more quickly, and to higher levels, in vented tapholes than in unvented tapholes.

Observations of stoppage of sap flow are difficult to pinpoint with respect to the exact day when sap flow ceased. Actually, one can detect sap flow stoppage in a taphole only when weather conditions exist that cause sap flow in other tapholes. Thus, one can only say on which day sap last flowed. At the beginning of the 1960 season, a sap run was good from all tapholes. For 19 days after February 28, the weather was cold; consequently, sap did not flow again until March 17. On that date none of the aerial-system tapholes were running. In contrast, only one of four unvented tapholes in the ground system had stopped running, and two of five vented holes.

DISCUSSION

As the season progresses and the weather warms, microbial growth rates accelerate, especially at night, and the population in sap is not entirely destroyed. Nevertheless, the effect of sunlight as a disinfecting agent is appreciable, and has also been demonstrated in polyvinyl plastic bags (Naghski and Willits, 1953). The end result of this inhibition of microbial growth in sap is sirup of a higher quality (i.e., lighter color). Since the spouts and tapholes are protected from contamination, the collecting season is correspondingly lengthened and the total sap crop increased.

This report is from preliminary observations made in the field during two maple seasons, 1958–59, and from experiment in 1960. The initial observation of the microbial population in maple sap collected with plastic tubing (Fig. 2) demonstrated that the systems were subject to entry of microorganisms, probably around the spout or other fittings and through handling. In the installation studied in 1960, the vent was a 4-ft piece of tubing leading vertically from the taphole to a point up on the tree. The aerial system, comprising 10 tapholes, had only a single vent, at the taphole furthest from the exit end of the tubing. The ground system, composed of individual tapholes feeding directly into larger conduits, was vented with a spout having two tubulations, one connecting with the conduit and the other with the vent tube.

Originally it was planned to test several methods of venting during the 1960 study to evaluate the degree to which contamination may enter via this system. Some vent lines were installed without any protection over the exposed open end; others were protected with either a small wad of cotton or were covered with a "Kapette" (plastic protective pipette cover manufactured by Nelson-Kapell, Inc., Los Angeles; mention of this name does not imply endorsement of this company by the Department of Agriculture over any other similar companies not named). However, dur-

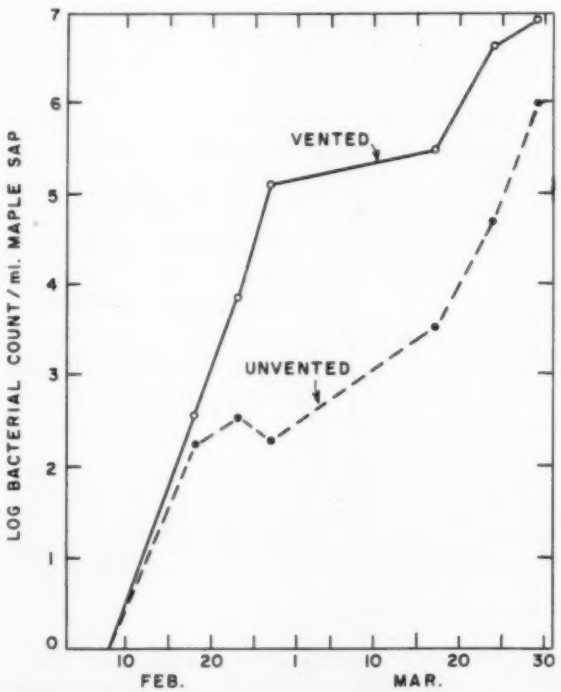

Fig. 4. Comparison of bacterial populations in maple sap collected with the ground tubing system using vented and unvented multiple tapholes connected in series.

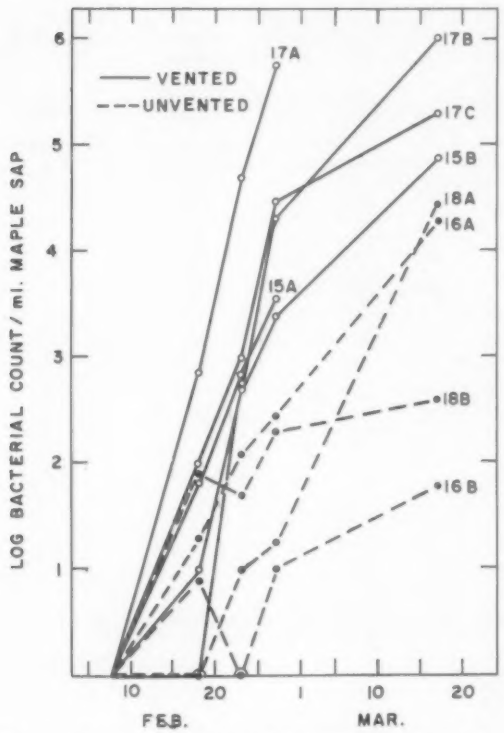

Fig. 5. Comparison of bacterial populations in maple sap from vented and unvented individual tapholes of the ground plastic-tubing collection system. Numbers identify the tree, and the letters identify the tapholes.

ing the first sap run we noted that imperfections in the vent systems prevented free escape of gas from the taphole. As a result, sap was being carried up the vent lines with the gas bubbles, and even running out the top of the vents. The Kapettes and cotton plugs became moist or were literally forced out of the tubing. Consequently, we removed all protection from the vent lines. Currently, work is being carried out to develop a spout that will separate sap from the entrapped gas bubbles and allow free escape of gas so that none of the sap will be carried into the vent lines. When completed, vented lines in this new system could be protected to keep out aerial contaminants.

It was hoped that some of our observations would elucidate the path of infection in the aerial system. The data in Fig. 3 are not clear-cut in this regard, however. The bacterial populations in sap coming from tapholes I through IV show a pattern of increase that might be expected if the more-downstream tapholes are being continuously fed with infected sap. This conclusion might seem unwarranted because taphole V, which is the most downstream of all tapholes and therefore should have the highest degree of infection, is rather low in bacterial count. The explanation, we feel, is fairly straightforward. The plastic lines connecting trees I through IV were suspended by anchoring the tubing to a groove in the spout, and then it was coiled and attached to the spout. The coil of tubing provided a pocket of sap that, during periods of non-flow, would serve as a "breeding place" for microbial buildup. Tree I had only one such coil, since it connected to only one tree (II); other trees in the line were connected to two trees. Tree V was the exception, since no coils were used on it. Instead, the line was anchored by wrapping around the tree, thus eliminating the static pocket of sap provided by the coil; this suggests an explanation for the lower bacterial count.

The use of multiple tapholes connected in series on a single tree emptying into a single line was studied since it provides a simpler means of collecting sap from a large tree without the expense of connecting the individual tapholes of each tree to the conduit. Fig. 4 shows that bacterial populations in vented systems of multiple tapholes connected in series are higher than similar systems not vented. The effects of venting individual tapholes (Fig. 5) are consistent with the effects shown in Fig. 4—that venting leads to earlier contamination of the sap.

The stoppage of sap flow tends to indicate that the build-up of taphole microflora is faster in the aerial system than in the ground system, whether vented or not. It is unfortunate that weather did not allow sap to flow between February 27 and March 17. Additional data in that period might well have shown that the aerial tapholes did not stop flowing simultaneously, but rather in accordance with their level of contamination, with trees V and I being the most long-lived.

That venting is desirable was apparent from observations on sap flow. Without exception, vented tapholes ran more freely than did unvented tapholes. It is not unreasonable to expect that some modification permitting free escape of gases will be forthcoming. If so, preventing or decreasing contaminants entering via the vent should be possible.

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Research Note

Thin-Layer Chromatography—A New Analytical Technique with Potential Applications to Foods*

(Manuscript received May 5, 1961)

THIN-LAYER chromatography was used in this country in 1951 for separating terpenes from citrus fruits at the U.S.D.A. Laboratory at Pasadena, California, by Kirchner, Miller, and Keller (1951). Their technique, chromatographing on narrow strips of glass coated with silicic acid, was modified in 1956 by Stahl *et al.* (1956), who developed a precision thin-layer applicator for use with wider glass plates. The use of silicic acid on glass for chromatography provides, in effect, an open column from which components can be removed readily by merely scraping the adsorbant from the plate and eluting it with solvent. Substances thus separated can be used for additional microtechniques. The separations, much more rapid than with column or paper chromatography, can be completed in minutes.

This technique did not receive much attention in this country until recently, when joint research at Hormel Institute, University of Minnesota, and Seattle Technological Laboratory, U. S. Bureau of Commercial Fisheries, widened its usefulness by showing its application to lipids and other classes of compounds (Mangold and Malins, 1960; Malins and Mangold, 1960).

As a result, interest increased greatly, and the new method is now in use in numerous laboratories, both in this country and abroad, for a wide variety of applications. The technique should interest food chemists, since it is rapid and adaptable to routine determinations. It has proved useful, for example, in the separation of such substances as vitamins, lipids, antioxidants, and other food additives.

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Technological Laboratory
U. S. Bureau of Commercial Fisheries
Seattle, Washington

* This is contribution no. 625 from the technological laboratories of the Bureau of Commercial Fisheries, Fish and Wildlife Service, U. S. Department of the Interior.

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Translation of Paper by Soviet Scientist

Challenges Claim That Russian Invented Canning

Georg Borgstrom
Department Food Science, Michigan State University

THE AUGUST, 1960, issue of FOOD TECHNOLOGY published a translation of an article by M. Gontcharov, from the Soviet meat journal "Myasnaya Industria SSSR." The article stated that the Russian scientist V. N. Karazine was the inventor of food canning, and that he introduced the use of metal cans.

Article Challenged

Two months later there was published a paper by W. Shipov, "The History of Meat Preservation in Hermetic Containers," which refuted the Gontcharov paper. The Shipov article can be considered important, and also presents some points of general interest.

Additional Facts Given

A few additional facts not mentioned in the Gontcharov and Shipov articles should be given here in the interest of better understanding.

It is fairly well documented that in 1794 Nicolas Appert was operating an experimental cannery at Ivry-sur-Seine, France. In 1804, Appert started the first commercial cannery near Paris, at Massy. In this same year, French maritime authorities certified to the high keeping properties of foods packed by "the citizen Appert."

The first French edition of Appert's book, which presented the results of 14 years of extensive research, was published in 1810. New editions followed in 1811 and 1813. This was far ahead of the alleged publishing of Karazine's monograph, in Moscow in 1829.

From this same year it is recorded that a Captain Ross discovered a camp erected in 1824 by Captain Sir Edward Parry, who was at that time searching for a North-West Passage. Several food packages were found unopened at the Parry camp site. These were brought back to England. One package, a six-pound canister of meat packed in 1823 by Donkins, Hall and Gamble, of Bermondsey, England, was opened in July, 1958, in London. The contents were still edible.

Publication Dates of Appert Book

By 1831, four French editions of Appert's monograph had been published. After his death three additional editions were published, in 1842, 1857 and 1858.

The original Appert treatise, published in 1810, was quickly translated into several languages. In that same year a German edition was published, followed by another in 1822. In 1811, it was published in English, Swedish, and Italian. A second English edition was published in that year, followed by a third in 1812.

The first U.S. edition of Appert's monograph was printed in 1812. But not until more than a century later were reprints made—in 1920 and 1921.

Background of British Theory

Numerous French biographies about Nicolas Appert state that the first factory employing the appertisation method using tin cans was started in England in the year 1814. This presumably accounts for the Kotzebue statement attributing the discovery of canned foods to the Britisher Donkins following the shipping of two cases of canned meats around the world by the Russian navigator Krausenstein. At that time, the assertion was vehemently protested by the French explorer, Louis de Freycinet.

Book Gets Through Blockade

It is interesting to note that the British were quick to seize upon the value of Appert's work during the time of war with France. History shows that a fisherman named Gerard was able to get Appert's book to England despite the prevailing war, and the then famous British Continental Blockade of Napoleon's France.

Translation of Shipov Paper

Following is a translation of the Shipov paper on the history of meat preservation in hermetic containers, which refutes the Gontcharov paper published in FOOD TECHNOLOGY. (Ed. Note: The translation was made by Professor Borgstrom.)

The Translation

The previous paper by M. Gontcharov (1) gives an erroneous presentation of the role played by the eminent Russian scientist, V. N. Karazine, in the development of our national canning industry. The facts presented in that article are not supported by available documentation.

The author states that "Unfortunately the information about this inventor and his works are extremely scanty in our literature and the search for documents on this subject have failed to give results."

This statement is not correct. In addition to the treatise by V. N. Karazine with the title "On The Most Appropriate Method for Preserving and Transporting for Long Distances Food Products, Originating in the Plant or Animal Kingdom in a Nutritious, Wholesome and Ready-for-Consumption Form," published in 1829, there is available a digest, "Selected parts of the completed works of V. N. Karazine from 1861," as well as a book, "Papers, Letters and Other Publications by V. N. Karazine," printed in 1910,

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and finally a biography by A. G. Slusorski, with the title, "V. N. Karazine—his Scientific and Social Activities," published in 1955. From these documented sources, quoted here, it can be deduced that V. N. Karazine was, in fact, very much occupied in studying experimentally and scientifically the problems related to the preservation of perishable foods through drying and smoking. In this particular area the priority belongs to him.

But when it comes to the discovery of preserving foods through sterilization at high temperatures in hermetically sealed containers — a discovery that Gontcharov and several other authors (2) attribute to V. N. Karazine—this is indeed refuted by Karazine himself in these very documents.

M. Gontcharov gives an erroneous interpretation of the meaning of the quotation extracted from the paper by V. N. Karazine in 1829 (3), in which the author develops the scientific basis for preservation through dehydration. He there laid down three basic principles, of which the third one is presented in the following words: "The nutritive and wholesome substances, some with curing qualities, do not constitute the entire volume of foods, whether of animal or plant origin. This is true both in the natural fresh condition as well as in the dry state. In fact, those constituents represent only a minor portion, sometimes only 1/20 or even 1/100. This fact started to attract the attention of Count Rumford in his making of liquid decoctions (broths and extracts). As regards myself I discovered these products and expressed those procedures mathematically in the form of figure relationships on the basis of experiments performed in St. Petersburg in the summer of 1815. These findings were presented to a scientific committee appointed by the government. See further No. 32 of the periodical "Synd Otchestva" (Sons of the Fatherland) in this very same year, which contains a short communication on this matter to the same national committee at the request of the State Secretary of War. However, the very first presentation of this subject and the reporting of the discoveries had already been made to governmental bodies, in 1806. Consequently they refer to a period much earlier than the experiments and studies of a corresponding nature made in foreign countries, and were partly based on experiments that are published in the Transactions of the Philotechnical Society of Charkov."

From this quotation it can be inferred that it does not at all refer to the preservation through sterilization in hermetically sealed containers, discovered in France by the culinary expert N. Appert in 1804, but to preservation through dehydration.

Attributing the discovery of canning in tin cans to V. N. Karazine may also be refuted on the basis of other quotations from this scientist himself.

M. Gontcharov further asserts in his article: "Following his procedures three cases of cans had been prepared that were loaded on a ship just departing for a tour around the world. After a trip lasting almost three years, the ship returned to St. Petersburg and the preserved food was re-expedited to Charkov."

Now let us see how V. N. Karazine describes this very same event in his narrative under the title "For the last four months of 1818," presented by him in the Philotechnical Society in 1819 (4).

"After my return from your latest congress I received from St. Petersburg a communication sent by M. Kotzebue, Commandant on the famous vessel Riourik, who had at the recommendation of our most Honorable Member, His Excellency the Chancellor of the Emperor, sent me two cases of fresh meat, originating in England. One case contained beef, and the second veal. These products were prepared in London on Febr. 2nd, 1815, according to our calendar, i.e., four years less ten days, prior to their arrival. They had toured twice around the globe, that is from the port of Kronstadt, then to the port of Petropavlovsk via Kamtchatka, and back. They had twice passed the Equator and the two tropical regions, through almost all kinds of climate. Consequently they had been exposed to all possible variations in atmospheric temperature taking place in the course of such a long trip. They had passed the Canary Islands, the coast of Brazil, over the seas of China, of Japan and those off Kamtchatka, between Asia and America. The cases had been returned to Europe and finally discharged in the port of St. Petersburg. Without any special precautions they had been sent by mail carriage on land to Charkov and finally to the village of Kroutchine. In spite of this, these perishable products had preserved their freshness, thanks to a chemical discovery that ancient people were not able even to conceive. These discoveries are particularly important to maritime navigation, to armies, and to all travelers."

From the preceding it is evident that M. Gontcharov and other authors have distorted the true facts. V. N. Karazine was the first inventor of liquid and dried extracts of not only bread, meat, and wine, but also that of the national cabbage soup, 'schchi.' He also invented the first method for preparing 'pyrolignic vinegar,' a smoking solution, the vapors of which allowed a reduction in smoking time for meat to three hours from, frequently, several weeks. The method of drying meat, suggested by V. N. Karazine, allows a reduction of five times in the weight in comparison to fresh meat, and this meat packed in a barrel remains consumable for more than one year. It constitutes a food product invariably superior to salted meat, which at present occupies such a large volume and induces scurvy after prolonged consumption.

It is on the basis of these facts that the priority resides as well as the great scientific weight of the investigations by V. N. Karazine. There is no reason to attribute to him things that do not correspond to reality.

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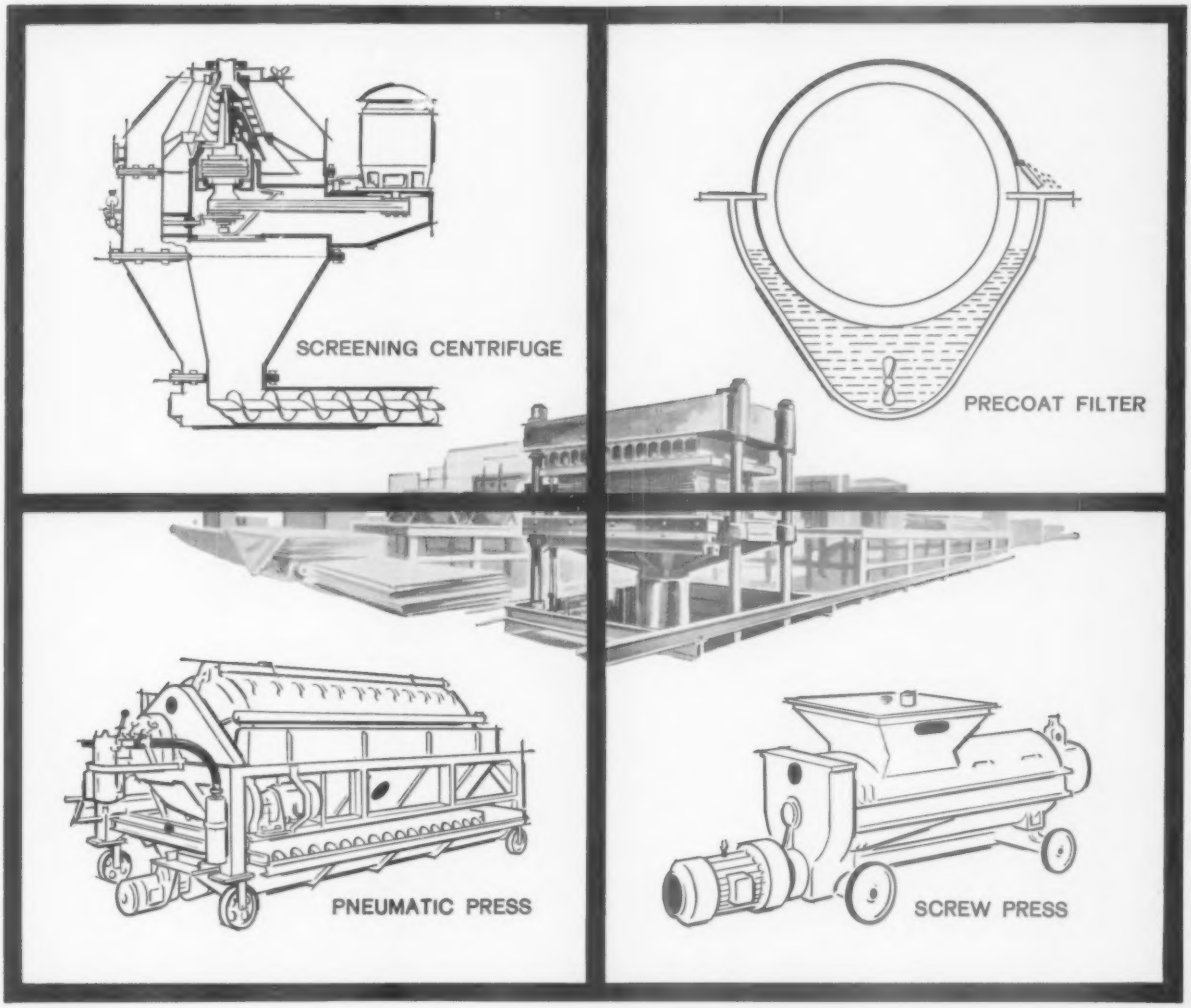

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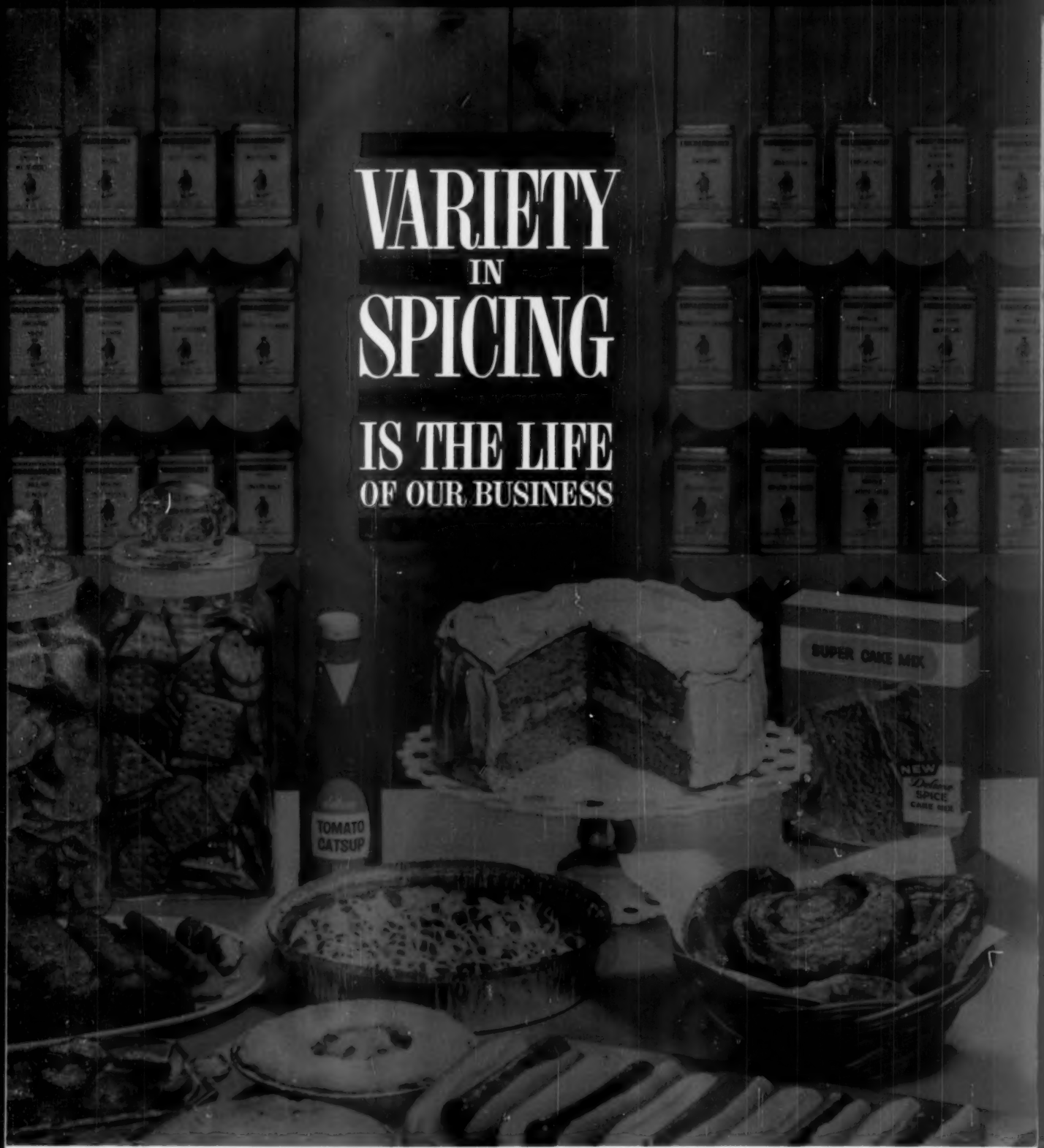

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International Food Technology

German Nutritionist Joins FAO Division Branch

Dr. Hans D. Cremer has joined the staff of the Food and Agriculture Organization on a two-year leave from his post as Chief of the Institute for Nutrition Science at Justus Liebig University, Giessen, Germany. Dr. Cremer will be chief of FAO's Nutrition Division, Applied Nutrition Branch.

Dr. Cremer's interests have been in the fields of nutritive value of proteins, the correlations between nutrition and dental caries, and the physiological actions of foreign substances.

The FAO Applied Nutrition Branch is concerned with helping member governments use modern knowledge of nutrition. This includes the establishment of nutrition services, training in nutrition, nutrition education programs, promotion of consumption of foods having high nutritive value, large-scale feeding and catering, and studies of cultural and socio-economic conditions as a basis for applied nutrition programs.

First Inter-American Congress Of Chemical Engineering

The First Inter-American Congress of Chemical Engineering will be held at San Juan, Puerto Rico, October 23–28, 1961.

Sponsored by the Institute of Chemical Engineers of Puerto Rico, the Congress is designed to contribute to the advance of chemical engineering in all its aspects. All countries in South, Central, and North America will participate.

The main activity will be presentation of technical papers during sessions devoted to: Sugar Technology; Food Technology; Technology of Alcoholic Beverages; Nuclear Technology; Petroleum Technology; Sanitary Engineering; Biochemical Engineering; Unit Operations; Industrial and Engineering Chemistry; Pure Chemistry; and Chemical Engineering Education.

Administrative sessions will deal with founding and organizing an Inter-American Society of Chemical Engineers as an answer to the prevailing need of a complete interchange of scientific and cultural knowledge.

Visits to important industrial areas of Puerto Rico, and social activities for delegates and their wives, have also been arranged.

Additional information may be obtained from: The Secretary, Institute of Chemical Engineers of Puerto Rico, P.O. Box 47, Rio Piedras, Puerto Rico.

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European Symposium on Food Technology

A Symposium on Food Technology, sponsored by the European Federation of Chemical Engineering, will be held in Frankfurt (Main) Germany on October 19 and 20, 1961.

The principal lectures will include: "Food Technology as an Example of Process Engineering," to be given jointly by Prof. **Dr.-Ing. J. Kuprianoff,** Karlsruhe (Germany), and Prof. **Dr. Ir. H. A. Leniger,** Wageningen (Netherlands); "Food Additives and Uniformity in International Food Legislation," to be delivered by Prof. Dr. med. E. Abramson, Stockholm (Sweden); and "Physiological Effects on Nutrition of the Processing of Foods," to be presented by Prof. Dr. med., Dr. phil. nat. K. Lang, Mainz (Germany).

The Symposium will also include discussions on heating and cooling, freezing, concentration and extraction, size reduction, mixing, drying, homogenization, evaporation and distillation, and packaging and transport.

Additional information on the Symposium may be obtained from the Secretary, DECHEMA, Frankfurt (Main) 7, Postfach 7746, Germany.

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Regional News

Speaking before the Dixie Section of IFT on April 7, IFT President Harold W. Schultz called for study of problems connected with both increasing the membership of IFT, and the services that the Institute should render to its members. He pointed to the probability that many new ideas and policies for the Institute would be forthcoming from the newly appointed Executive Secretary, and Journal Editors.

Dr. Schultz also stated that the professional status of IFT should be improved so that Government and Federal agencies would seek out the Institute more often for advice and help.

Coming Events

1961	
Sept. 5–8	11th National Chemical Exposition, International Amphitheatre, Chicago, Illinois
Sept. 11–13	Symposium on Foods: Oxidative Deterioration of Food Lipids. Oregon State University, Corvallis
Sept. 11–15	16th Annual ISA Instrument-Automation Conference and Exhibit, Los Angeles, California
Sept. 11–15	Marine Science Instrumentation Symposium, Woods Hole, Massachusetts
Sept. 15–19	American Meat Institute, Palmer House, Chicago, Illinois
Sept. 19–22	Food Science Conference, C.S.I.R.O., North Ryde, N.S.W., Australia
Sept. 19–27	International Conference on Fish in Nutrition, Washington, D. C.
Sept. 28–30	American Hotel Association, Washington, D. C.
Oct. 7–12	Baking Industry Exposition, Convention Hall, Atlantic City
Oct. 15–18	National Association of Food Chains, Palmer House, Chicago, Illinois
Oct. 18–20	National Packaging Forum of Packaging Institute, Biltmore Hotel, New York City
Oct. 16–19	Second International Congress of the International Organization for Vacuum Science and Technology, Washington, D. C.
Oct. 19-20	European Federation of Chemical Engineering Symposium on Food Technology, Frankfurt/Main, Germany
Oct. 23–28	First Inter-American Congress of Chemical Engineering, San Juan, Puerto Rico (write Institute of Chemical Engineers of Puerto Rico, P. O. Box 47, Rio Piedras, Puerto Rico)
Oct. 24–27	American Dietetic Association, Jefferson Hotel, St. Louis
Oct. 28–31	National Automatic Merchandising Assn. Convention and Exhibit, Chicago, Illinois
Nov. 5–8	National Frozen Food Association, Bal Harbour and Americana Hotels, Miami Beach
Nov. 6–10	National Hotel Exposition, Coliseum, New York City
Nov. 12–15	Air Conditioning and Refrigeration Institute, Homestead Hotel, Hot Springs
Nov. 15	British National Association of Wholesale Distributors of Frozen Foods—Annual Lunch, Trocadero, London
Nov. 27–Dec. 1	28th Exposition of Chemical Industries, New York Coliseum
Dec. 1-3	National Automatic Merchandising Assn. Western Conference and Exhibit, Los Angeles, California
1962	
Feb. 9–11	Institute of American Poultry Industries' 33rd Annual Fact Finding Conference; Municipal Auditorium, Kansas City, Missouri
June 10–14	**Twenty-second Annual Meeting of the Institute of Food Technologists, Fontainebleau Hotel, Eden Roc Hotel, Miami Beach, Florida**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, P. O. Box 164, Davis, California, notices of annual or national meetings of interest to food technologists.

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Literature

Book Reviews

RESEARCH AS A SCIENCE—ZETETICS, by Joseph T. Tykociner. 205 pages. Electrical Engineering Research Laboratory of the University of Illinois. Distributed by Joseph T. Tykociner, 306 West Iowa Street, Urbana, Illinois. $2.00.

The impression of this work on reading the first 20–30 pages is that we are witnessing the effort of a reformer as he examines research to prescribe for its needs. Author Tykociner, in such a light, appears to see research broadened to so-called "Zeteties" as a tool to reform science and technology. Seeking further, the reader finds that the author is not a mere reformer in the "do gooder" sense but a true scientist and pioneer.

Many interesting definitions of old terms appear as the author develops his subject. Also, there are definitions of newly coined words and terms; at least eight new words or terms are derived from the Greek for elucidation of the subjects in "Zeteties," itself a new word. Also, at least three new mathematical symbols are presented to the reader.

The logarithmic development of quality (and quantity?) of knowledge with time is well presented. How problems originate, and the relation of Zeteties' systematic approach to the normal procedure of the human mind is exemplified when several scientific disciplines approach the subject of fire, for example. This in turn leads to the subject of teamwork in research, the outstanding example being the International Geophysical Year.

The reader is richly rewarded toward the middle of the book in a human-interest account of the invention of sound motion pictures and the author's analysis of the true meaning of serendipity (accidental discovery).

Part two provides basic material for an inventory of arts and sciences and includes appendices relative to cataloging and information retrieval necessary to this systematic science of sciences.

WILLARD E. BAIER

TEXTURE IN FOODS. S.C.I. Monograph No. 7. Society of Chemical Industry. London. 1960. 184 pages.

This small volume comprises the papers presented in October, 1958, at a symposium of the Food Group of the Society of Chemical Industry. Each paper is concerned with some aspect of the texture of food materials, and all represent viewpoints and research interests of workers in this field in the United Kingdom. Unfortunately, there is no introduction, and no unifying theme can be identified among the various presentations.

In the first group of papers, R. C. Oldfield succinctly reviews physiological and psychological aspects of texture perception in the mouth, and points to problems of significance to all concerned in texture evaluation. The next three papers take up special problems in certain confectionery products and food emulsions, principally from the standpoint of technology of manufacture. The group is concluded by a discussion, primarily on interesting psychological questions arising from Prof. Oldfield's review.

The second group embraces, first, a detailed presentation of dissociation behavior and rheological measurements with pectin gels. This paper, based on the doctoral dissertation of H. G. Harvey, covers 34 pages of text and includes much new material on the formation of the high sugar pectin gel. Following are a consideration of texture measurement in baked goods and a review of problems in chocolate texture. The final paper in the group, by G. W. Scott Blair, deals with the scientific rank of different kinds of measurement in texture appraisal. Dr. Scott Blair also takes up the intriguing question of the dimensional value of "firmness." The group ends with a discussion.

The third group consists of a paper on methods of measuring meat tenderness, a report on texture change in frozen fish and its measurement, a review of chemical aspects of pea texture, a report on the dry-matter content of different British varieties of potato, a review of composition of the cell wall in plant tissues, and a discussion.

The last group contains a presentation of the work of the late J. Brooks and a short general discussion. The group covers Dr. Brooks' interesting studies on rheological properties of egg shell, on the thick white of the egg, and on the vitelline membrane about the yolk.

Generally, this book is not oriented toward the average food technologist. It will be most useful for the research worker interested in textural problems as such or in a particular aspect of texture in one of the special commodities covered. It is a pity that there is no general purview or basic set of information that would be of value to the student or to an uninitiated food scientist. It is even more unfortunate that the treatments (mostly rather abbreviated) are quite uneven. Thus, some papers review only a limited portion of relevant work (as in potato texture) while others deal with a very specialized topic from a restricted point of view (as in candy texture). As a rule, the treatments tend to be empirical and mainly phenomenological. Concerning molecular relationships, little more than a few speculative remarks can be found.

The value of the book lies in its major emphasis on the problems remaining. From this standpoint, it may serve to inspire further work and point out the directions that demand more investigation.

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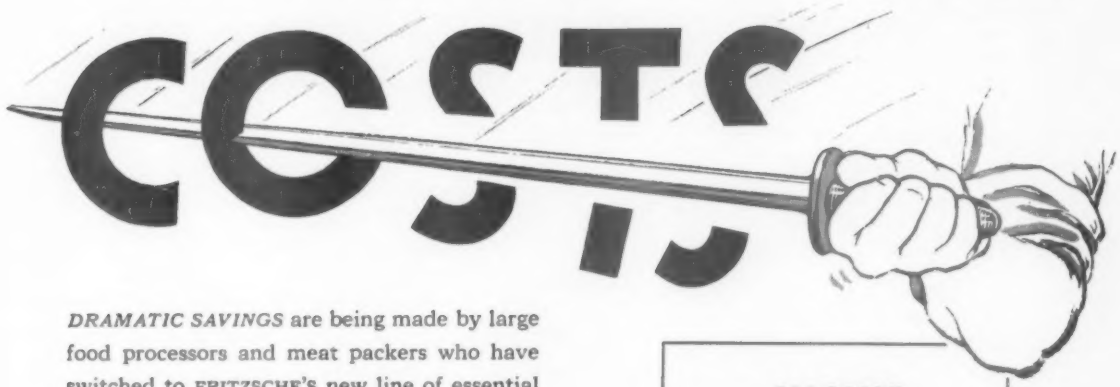

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"A Suggested Employee Relations Campaign for Better Housekeeping" is the subject of a new 10-page pamphlet just issued by **Puritan Chemical Company.** The pamphlet gives guidance to manufacturers, food processors, and business firms who are interested in an all-employee drive for better housekeeping on the job. It tells how to organize and conduct the campaign, and it includes samples of promotional items that may be used. Copies may be obtained by writing for Engineered Maintenance Pamphlet No. 11, Puritan Chemical Company, 916 Ashby Street, N.W., Atlanta 18, Georgia.

A new bulletin describing the CP Series "90" Multi-Process Tanks has just been released by **The Creamery Package Mfg. Company,** Chicago. The maker claims these tanks are ideal for heating and cooling all liquid products including buttermilk, soups, and other heavy-bodied products. Designed for 10 in. of vacuum or 15 p.s.i. pressure, the tanks are of stainless steel and are available in pressure-processing or unloading sizes from 300 to 2,000 gallons capacity. Further information may be obtained by writing for Bulletin B-1-190, The Creamery Package Manufacturing Company, 1243 W. Washington Blvd., Chicago 7, Illinois.

Spraying Systems Company recently published its new Bulletin 108, featuring Spraying Systems Spraydry Nozzles for spray drying. The 12-page bulletin describes, illustrates, and lists all capacities of the company's line of nozzles for spray drying such products as milk, eggs, coffee, soy products, and related products and chemicals. Also included are high-pressure strainers and general information of interest relative to spray nozzle application. For a copy, write Spraying Systems Company, 3201 Randolph Street, Bellwood, Illinois.

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People

K. Gene Mattice has been named Manager, Northwest Sales, of the C and H Sugar Refining Corporation. He will be responsible for all C and H sugar sales in the Pacific Northwest, and coordinate sales of grocery products and industrial products in Oregon, Washington, and Idaho. Mattice joined C and H in Portland in 1953, and has worked with food processors as a northwest technical service representative. He graduated from Oregon State University with a degree in food technology.

K. G. Mattice

The appointment of **Dr. Conrad E. Kruse** to the teaching and research staff of the biological sciences department, Drexel Institute of Technology, has recently been announced. Dr. Kruse has had extensive experience in the field of food technology, particularly in frozen foods and the microbiology of meat products, as well as packaging problems and new-product development.

Robert E. Parker has been appointed Quality Control Manager at Western Condensing Company, Division of Foremost Dairies, to replace **Ara O. Call,** who recently resigned to accept a missionary assignment. Since joining Western in 1947, Mr. Parker has worked extensively in various product-control and development capacities, including Director of Central Control Laboratory. He is a graduate of the University of Minnesota, where he specialized in Agricultural Biochemistry.

R. E. Parker

Raymond Ross

Raymond Ross, a member of the New York sales staff of Florasynth Laboratories, Inc., was recently honored by the company after completing 25 years of service with the organization. Ross entered the employ of Florasynth in the flavor laboratory, and remained there for five years. He received a promotion to the sales department and has continued in this capacity up to the present except for three years in the Armed Forces.

The Department of Food Science and Technology at the University of California, Davis, has appointed **Dr. Mendel Mazelis** to develop its research and instruction programs for the important field of frozen food preservation.

In announcing the appointment, Dr. George F. Stewart, department chairman, said that Dr. Mazelis will spend considerable time with the frozen-food industry in a joint effort to improve technical advances in this increasingly important segment of the food industry.

Dr. Mazelis comes to the U. C. Department of Food Science and Technology from the USDA Western Regional Laboratory, Albany, California, where he has been a member since 1957 of that organization's Vegetable Compositions Investigations Group, studying precursors of the flavors and odors of vegetables, and the metabolic pathways and enzymes that give rise to the products responsible for these characteristic flavors or odors. In this research area, Mazelis concentrated on fundamental studies of the metabolism of the sulfur-containing amino acids in higher plants. At the same time, his investigations brought him into contact with many of the practical aspects of the frozen-food industry, particularly in relation to some of the enzymatic changes in the raw product during processing.

Before joining the Western Regional Laboratory, Dr. Mazelis was on the research staffs of the Department of Biochemistry at the University of Chicago, and the Department of Plant Biochemistry at the University of California, Berkeley.

A graduate of Roosevelt High School, Los Angeles, Dr. Mazelis received the B.S. and Ph.D. degrees from the University of California, Berkeley. He is a member of the American Society of Plant Physiologists and of Sigma Xi.

Dr. Mazelis, 39, is unmarried. He lives with his mother, Anna, at 4723 Castilla Ave., Richmond, Calif.

Expansion News

A $700,000 electronic plant in East Bridgewater, Mass., was opened June 5th by **The Foxboro Company,** Foxboro, Mass. Employing a staff of 150, the new 40,000-sq-ft plant will allow Foxboro to expand the manufacture and assembly of Electronic Consotrol Instruments. The ultimate aim is to expand to handle demands for electronic instrumentation in all phases of industrial processing. The new plant brings The Foxboro Company total to six factories and branch factories within the United States, not including repair shops and 61 branch offices. Internationally, besides four manufacturing plants in England, Holland, Canada, and an associated plant in Japan, there are 45 engineering firms representing Foxboro throughout the world.

The opening of a **Foremost Dairies, Inc.,** franchised Golden State Company, Inc. (Philippines), plant in Manila, was announced recently. Ceremonies at the 40,000-sq-ft plant, in Makati, a new industrial district of Manila, were attended by such prominent individuals as President Carlos P. Garcia, chief executive of the islands, and United States Ambassador to the Philippines, John Dewey Hickerson.

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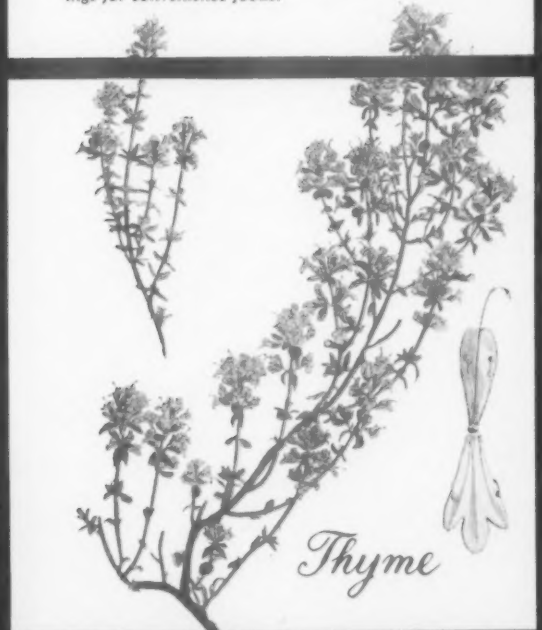

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News

A RUSSIAN PROGRESS REPORT ON USE OF RADIOACTIVE ISOTOPES

The concluding sentence of a release put out by the Press Department of the Russian Embassy in Washington reads: "The tremendous energy of the peaceful atom evoked by the genius of Soviet science brings great benefit to man." This is included in an article titled "The Atom Serves Man," by G. Porutsky, M.Sc. Biologist. It appears that the source of the article is: (*Pravda Urkainy*, Feb. 12, 1961. Slightly abridged.)

So that the editors of FOOD TECHNOLOGY may not be accused of adding to the strains of relationship, the article is here published exactly as it was received:

"The processes employed in the food industry of today are becoming more complicated, and it has to rely on automation more and more. That makes the requirements for different instruments more stringent. The explanation? The more exact control, the better is the processing of raw materials.

Radioactive isotopes afford wider possibilities for instrument-making. Special counters easily detect radioactive isotopes anywhere. Available in a great variety and at low cost, radioactive isotopes or tracers, as they are called, may well help to solve many important problems in the automation of complex industrial processes. We have already developed and put out a large number of different radioisotope-based instruments for in agriculture and the food industry. This holds out a special promise to biologists and agronomists.

For instance, great progress has been made in the physiology of nutrition. This has led to the reappraisal of the nutritional value of farm products. In the past, food products and forage were judged by their caloricity, i.e. by the amount of calories they contained. But now other principles of evaluation are coming to the foreground and that considerably alters the planning of food production. Take, for instance, proteins. Formerly what interested people was the amount of proteins a food product contained, but now the amount of indispensible amino acids it contains is considered of primary importance. The amino acids lysine, tryptophane, phenylalanine, leucine, isoleucine, trionine, methionine and valine are indispensible to man. A shortage or absence of these amino acids in the food we eat causes disease. Proteins, including those contained in different kinds of grain differ in their amino acid composition. This makes imperative the thorough study of the amino acids of food products and raw materials, which can be best accomplished with the help of tracer elements.

Considerable progress has been made in our evaluation of fats. Formerly animal (milk) fat was considered the best. However, it was found that animal fats contain a smaller amount of certain indispensible fatty acids (linolic and linolenic acids) which cannot be synthetized in the human organism. On the other hand animal fats contain a great amount of cholesterol which favours the development of sclerotic changes in the wells of blood vessels.

As the researches conducted in the Institute of Plant Physiology of the Academy of Sciences of the Ukrainian S.S.R. have shown the tracer method will play a leading role in the study of the biological synthesis of proteins and fats.

All branches of agriculture are faced with the task of improving the quality of food raw materials, but, first and foremost, it must be tackled by plant and animal breeders. Wheat breeding may serve as an example. With the help of methods of physiological control including the tracer technique Academician V. Yuryev, Hero of Socialist Labour, has bred many valuable wheat varieties with very good baking qualities. The Hero of Socialist Labour F. G. Kirichenko, Lenin Prise Winner, produced a new durum winter wheat variety "Michurinka" which gives an average yield of 36.5 centers per hectare. It contains by 2–4% more protein than soft winter wheats.

Yet to this day wheat varieties possessing very poor baking qualities and inferior gluten are still being sown.

In plant breeding the physiological indices of quality should always be taken into consideration. That is why it is necessary to restore plant physiology departments working on modern methods and supplied with the necessary equipment in the plant breeding and regional stations.

Tracer technique is employed in agriculture to gain better knowledge of the different life processes in plant and animal organisms in order to increase their productivity, to evaluate methods of applying fertilizers, soil cultivation, plant nutrition, feeding and rearing animals, and also to find such means of procuring and storing raw materials as would help preserve their good quality.

By the tracer method it was disclosed that phosphorus accumulates primarily in young tissues, especially in the growing points, and calcium in older organs. This shows how important it is to place phosphate fertilizers in the rows, lime and dung should be introduced not only before deep ploughing but also placed in rows or holes before cultivation.

S. Cherednichenko, M.Sc., head agronomist of the "Shakhter" grain state farm for a period of four years topdressed winter wheat and corn with radioactive phosphorus. He got an increment in grain yields of up to 3 centers per hectare not only in the first but also in the following generations.

Fertilizers containing tracer elements are being produced in the U.S.S.R. — radioactive superphosphate and other kinds of phosphates and calciferous manures as well as means of weed control.

The importance of studying the physiology of the action of nuclear radiation can hardly be overestimated. This kind of radiation exerts its influence on diverse phenomena. Michurin believed it possible to create frost-resistant peaches and new plant varieties with the help of the energy of cosmic rays, X-rays, ultraviolet rays and ionization. Valuable results

No, But He Knows What He Likes! This stalwart minion of the law never tasted quail's tongues. But he's an authority on the more substantial "groceries". If he doesn't savor the flavor the first time, there'll be no second time. Felton Flavors supply the taste he likes. Like all Americans, he's adventurous in his tastes. The same old flavors weary him. He seeks new taste sensations. For 38 years, Felton has been giving old foods new taste and inspiring the creation of new foods. If you want to revitalize an existing product, or dream up a new one, send for the man from Felton—taste-makers of the nation. Felton Chemical Co., Inc., 599 Johnson Ave., Brooklyn 37, New York.

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were obtained by applying tracer method in the study of such an extremely important biological process as photosynthesis, i.e. nutrition of green plants by carbon assimilation accomplished by the chlorophyll pigment with the help of luminous energy. In the process of photosynthesis plants produce from carbon dioxide and water organic substances which they need for the building of their organs and for their life processes. Contrary to former ideas about the products of photosynthesis, it was found by means of the tracer method that as a result of the transformation of tremendous streams of sunlight into chemical energy not only carbohydrates are formed in the chlorophyll grains but also proteins, amino acids, organic acids and vitamins.

If plants are well supplied with nitrogen their chloroplasts produce more proteins and amino acids than carbohydrates. Changes in the solar spectrum during the different hours of the day disclose this regularity. Therefore, the practical tasks consists not only in ensuring a high intensity of photosynthesis but altering it qualitatively in the required direction. That is precisely what K. Timiryazev urged.

With the help of labeled carbon dioxide it can be easily shown that if plants are well supplied with water the products of photosynthesis rapidly flow into the spikes and ensure their steady growth, ripening of the grain, and, in the final analysis, the production of high quality gluten.

By employing radioactive isotopes it becomes possible to work out the physiological basis of the progressive stepwise method of drying grain, especially seed material and in particular corn. The problem of preserving the quality of oil plant seeds in storage is being successfully solved by means of gamma radiation. Methods of storing potatoes, fruit and vegetables for a period of two years are being introduced into practice. They are based on the utilization of radiation.

An experimental apparatus has been constructed in the Nutrition Institute of the Academy of Medical Sciences of the U.S.S.R. for wide-scale industrial tests which will help to solve the problems of utilizing irradiated potatoes for food and technical purposes. Similar tests are being conducted in the Institute of Plant Physiology of the Ukrainian S.S.R. with sugar beet and corn seeds in order to employ the irradiation method at the seed sorting mills. Radioactive isotopes are becoming indispensible aids to plant breeders in the creation of highly productive superior quality farm crop varieties. The tremendous energy of the peaceful atom evoked by the genius of Soviet science brings great benefit to man.

The Robert A. Taft Sanitary Engineering Center announces a training course on: "Determination of Antibiotic and Pesticide Residues in Dairy Products." It is scheduled for presentation in Cincinnati, Ohio, October 9–13, 1961.

Applications or requests for information about this course (72M), should be addressed to: Chief, Training Program, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio, or to a PHS Regional Office Director.

FIFTH INTERNATIONAL FOOD CONGRESS AND EXHIBITION

The Fifth International Food Congress and Exhibition will be held in the New York Coliseum, New York City, from September 8 through September 16, 1962.

Major exhibits of the food and equipment manufacturers will present the accomplishments and future of the world-wide food industry. Other highlights will include evolution of the retail store, home economics, electronics, automatic merchandising, packaging, research and development, and materials handling.

Inquiries concerning exhibit space should be addressed to Exhibition Manager, Fifth International Food Congress and Exhibition, 1849 West 24th Street, Cleveland 13, Ohio.

Inquiries concerning the Congress should be addressed to the Secretary, Fifth International Food Congress, Inc., 527 Madison Avenue, New York 22, New York.

POULTRY INSPECTION SCHOOLS INITIATED

The University of Georgia and the Poultry Inspection Branch, Poultry Division, AMS, USDA, have cooperated in conducting a series of schools for veterinary personnel concerned with poultry inspection. Three schools were held in 1961, with some thirty supervisory veterinarians in attendance at each school.

The purpose of the schools was to review intensively the basic physiology, bacteriology, anatomy, and pathology germane to post-mortem inspection of poultry products. A further objective was to strengthen the working relationship of the USDA Inspection Branch with industry through the study of processing and plant production problems.

The University of Georgia's Food Technology Department supplied laboratory facilities during the schools. Staff members of the University's Food Technology and Poultry Departments, and the School of Veterinary Medicine, participated in the program.

OREGON STATE SYMPOSIUM ON FOODS

A second biennial "Symposium on Foods" will be held at Oregon State University Sept. 11 through 13.

Theme for the conference will be "Oxidative Deterioration of Food Lipids," a major problem in the manufacture and storage of food.

Arranged by the University's Department of Food and Dairy Technology, the symposium will bring together leading U. S. and foreign authorities for discussions

on the undesirable chemical reactions occurring in man's food supply and their implications pertaining to the human diet.

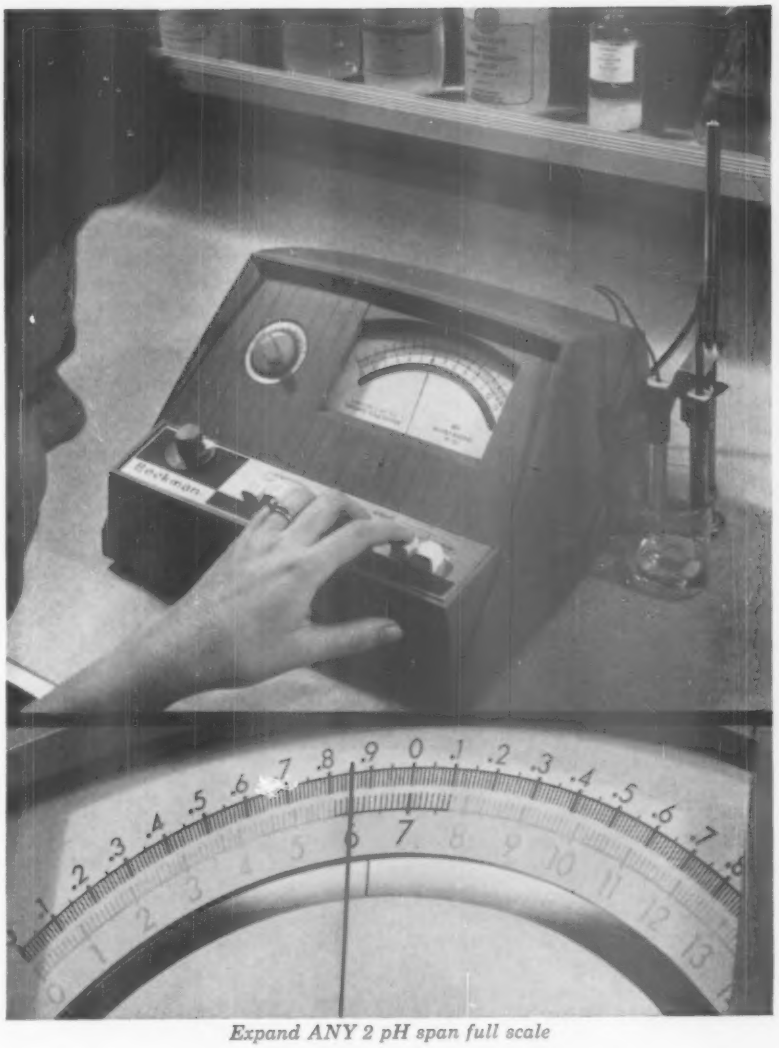
Sixteen authorities on lipid oxidation will speak during the three-day conference, which will include Dr. C. H. Lea, Cambridge University, England, and Dr. Noboru Matsuo, Tokyo Medical College, Japan.

Symposium chairman Dr. Harold W. Schultz, IFT President and head of the Department of Food and Dairy Technology at Oregon State University, states that the conference is designed to provide an atmosphere for a scholarly and coherent treatment of the forefront of knowledge on selected topics that are of either current or potential significance to man's food supply.

Industry News

Speas Company, Kansas City, Missouri, is offering a new apple pectin called BA-JEL, which is being used in the manufacture of bakers' jams and jellies. The advantage of this pectin, according to Speas, is that it promotes better heat stability in baking, and also decreases the amount of syneresis. For more information, write Paul Egerstrom, Executive Vice President, Speas Company, 2400 Nicholson Avenue, Kansas City 20, Missouri.

Modernlab engineers, with the cooperation of nuclear scientists, have developed an oven for particle reduction at elevated temperatures. Design of this oven is said to prevent undue loss of processed material, and electronically maintains close control of high temperatures to prevent unwanted chemical reactions. The oven is designed to operate continuously at 500 to 600°. Until recently, the manufacturer states, production of these ovens was limited exclusively to government and semi-government research and testing laboratories. Further



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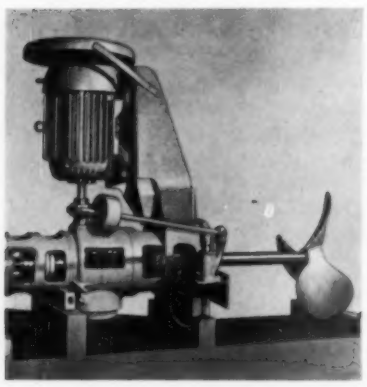
details from Modern Laboratory Equipment Company, Inc., 1809 First Avenue (94th Street), New York 28, New York.

A new, inexpensive Hand and Dipping Refractometer is announced by **American Optical Company's** Instrument Division. Juices, jams, jellies, soft drinks, syrups, and alcoholic beverages may be tested by using a two-drop sample. Internal temperature compensation precludes use of thermometer and/or conversion tables, yet results are equivalent to accuracy achieved by laboratory refractometers, according to American Optical. Questions should be directed to American Optical Company, Instrument Division, Buffalo 15, New York.

Waters Associates, Framingham, Mass., announces a new In-Line Refractometer. The instrument is designed to measure fluid process streams that previously could not be measured accurately because they were highly viscous, extremely dark, or opaque, or because the physical character changed when a sample was removed from the process. For information, write Waters Associates, 45 Franklin Street, Framingham, Massachusetts.



A new range of side-entering LIGHTNIN NSE mixers, said to achieve 50% greater flow or blending capacity while installation and operating costs are reduced by as much as 50% in larger-unit sizes, is announced by **Mixing Equipment Company, Inc.** A completely new design of super-pitch propeller offers improved hydraulic efficiency on both NSE and auxiliary RSE mixers. The net result of these new lines, states the manufacturer, is lower equipment cost and installation expense, lower power requirements, and larger mixing volumes for equivalent horsepower. For additional information, write Mixing Equipment Company, Inc., 170 Mt. Read Boulevard, P. O. Box 1370, Rochester, New York.

Labline, Inc., has introduced what is claimed to be the only line of baths on the market with magnetic, rotary stirring action. The magnetic stirring bar is energized from below the chamber by a non-sparking, induction motor, and uniform circulation is achieved with a flow director that surrounds the stirring bar and helps direct the water flow throughout the chamber. Write for Bulletin No. 4 for full information and prices from Labline, Inc., 3070 W. Grand Avenue, Chicago 22, Illinois.

Whole fresh lemons, including seeds and rind, are now being successfully spray dried to a stable powder, according to **Test Laboratories, Inc.,** Reseda, California. By liquefaction of rind, seed and pulp, followed by special spray drying techniques, the lemon is reduced from a 90% moisture form to approximately 5% as a powder. Supplementation of nutrients by salvage of rind, protopectins and seed provides a more nutritionally complete product, which is claimed to retain its values under normal storage conditions. Test Laboratories spokesmen state that the new lemon powder actually offers a greater ratio of nutrients than available in fresh lemons, because seed and rind can be utitlized in the powder form, while these sources of nutrition are lost in the consumption of the fresh lemon.

A new line of standard Series 7000 Digital Data Recording and Alarm Scanning Systems for the automation of food-processing plants has been announced by **Monitor Systems, Inc.,** a subsidiary of **Epsco, Incorporated.** Series 7000 systems utilize the "building block" technique throughout. They can be used to scan any variable that is reducible to electrical form at speeds ranging from those of typewriter readout devices to speeds of presently available magnetic-tape recording units. Systems with accuracies to 0.01% are available, as are computing functions, self-check, and self-repair features. For information, write Monitor Systems, Inc., Dept. 22, Fort Washington Industrial Park, Fort Washington, Pennsylvania.

A new solution to the problem of how to impart rich golden color to broilers and egg yolks is submitted by **Grain Processing Corporation.** Called A-ZANTH, a natural fermentation product of a recently isolated strain of algae, the product has been proved a safe and wholesome pigmentation agent with a stabilized and guaranteed xanthophyll potency, according to the manufacturer. For information, write Grain Processing Corporation, Muscatine, Iowa.

Advertisers' Index

*Air Reduction Sales Company
*Allied Chemical Corporation
*American Can Company
American Food Laboratories....16, 17
*American Sterilizer Company
*American Viscose Corporation
*Archer-Daniels-Midland Company
*Archibald & Kendall, Inc.
*Aseptic Thermo Indicator Company
*Bausch & Lomb Optical Company
Beckman Instruments, Inc. 45
Blumenthal Bros. Chocolate Company 23
Clinton Corn Processing Co. 9
*Continental Can Company....362A
Corn Products Sales Company....21
*Dairlyland Food Laboratories, Inc.
*Diamond Crystal Salt Company....374B
Distillation Products Industries....24, 25, 368B
Dodge & Olcott, Inc. 41
Dorr-Oliver Incorporated....12
*The Dow Chemical Company
*Dragoco Inc.
Drake Personnel, Inc. 48
Paul A. Dunkel and Co. Inc. 33
Durkee Famous Foods....22
*Eastman Chemical Products, Inc....368A
*Evans Research
Felton Chemical Company, Inc. 43
Firmenich, Inc. 11
Flavorex Co., Inc. 13
*Florasynth Laboratories, Inc. 350B
Food and Drug Research Laboratories, Inc. 48
*Food Machinery & Chemical Corporation
*Food Materials Corporation....356B
The Foxboro Company 18
Fries & Fries, Inc. 19
Fritzsche Brothers, Inc. 37
*Girdler Process Equipment Division Givaudan Flavors, Inc. ....3rd Cover
The Griffith Laboratories, Inc. 15
*Hercules Powder Company, Inc. 356A
*Hoffmann-La Roche Inc. 350A
*The Hubinger Company
*Chas. L. Huisking & Co., Inc. (Glyco)
*Information for Industry, International Flavors & Fragrances Inc. ....2nd Cover
Kelco Company 39
*Klenzade Products, Inc.
Knickerbocker Mills Co. 32
*H. Kohnstamm & Co., Inc.
*Kraft Foods 362B, 362C
*Macbeth Daylighting Corp.
*Magnus, Mabee & Reynard, Inc.
*Manton-Gaulin Manufacturing Co., Inc.
*Meer Corporation
*Merck & Co., Inc.
Miles Chemical Company 4
*Morningstar-Paisley, Inc.
Morton Salt Company 2
*The National Drying Machinery Company
*National Starch & Chemical Corporation 374A
*The Nestle Company Inc.
Norda Essential Oil & Chemical Company, Inc. ....4th Cover
*Henry H. Ottens Mfg. Co.
*Patterson-Kelley Co., Inc.
*Penick & Ford, Ltd., Inc.
*S. P. Penick & Company
Chas. Pfizer & Co., Inc. 28, 29
Photovolt Corporation 33
*PFW Proctor & Schwartz, Inc. 34
*RCA Industrial Electronics Products
*Refined Syrups & Sugars, Inc.
*Reinhold Publishing Corp.
*RePP Industries, Inc.
*Research, Inc.
*Reitz Manufacturing Co.
F. Ritter & Company 26
Rohm & Haas Company 31
*C. G. Sargent's Sons Corporation
Schwarz Laboratories, Inc. 48
Scientific Associates 48
*Speas Company
*Wm. J. Stange Company
Sterwin Chemicals, Inc. 35
*Sugar Information, Inc.
*Swift & Company
*Truesdail Laboratories, Inc.
*S. Twitchell Company
*Ungerer & Company, Inc.
*Union Carbide Chemicals Company
*U. S. Stoneware Company
*United States Testing Co.
*Urschel Laboratories Inc. 362D
*Vanilla Laboratories, Inc.
*Verona Aromatics
*Virginia Dare Extract Co., Inc.
Warner-Jenkinson Manufacturing Company 1
*R. D. Webb & So., Inc.
*Western Condensing Company
*John Wiley & Sons, Inc.
Wisconsin Alumni Research Foundation 48

* Advertisements appearing in technical section.

• Advertisers appearing in previous 1961 issues.

SITUATIONS WANTED

Reply directly to ad BY BOX NUMBER (where indicated) via: Executive Secretary, Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois.

FOOD RESEARCH CHEMIST (M.S.) with writing and administrative skills seeks challenging, responsible position. 11 yrs. exp. with wide variety of foods includes Product Development, Analytical Methods Development, Sensory Evaluation Techniques, Research Administration and Quality Control. Salary $9,500. REPLY BOX 885.

CHEMIST-FOOD TECHNOLOGIST: Desires responsible, growth position with medium sized company. Offers 18 years diversified, technical experience (research, development, production), managerial experience, initiative and flexibility. REPLY BOX 876.

AVAILABLE: Food Technologist, B.S. Purdue 1948. Some graduate work. Experience—canning, carbonated beverages and dairy products. Desire Chicago location. REPLY BOX 873.

Experienced individual desires to represent ingredient manufacturer to food processing industries. Well qualified for technical sales, sales, or sales service capacities. Prefer West Coast. Will consider other locations. BOX 890.

Management technical advisor. Academic, industrial, and consulting experience in bacteriology, biochemistry, and food technology problems and new product development. Salary area, $15,000. REPLY BOX C-2106.

MARKETING MAN—15 years in Market Development, Market Research, Promotion and Sale of food ingredients and related materials. Chemical degree and administrative experience. Now in organic chemicals, want out. Please write BOX 892.

Position as quality control technologist or supervisor desired by individual with experience in juices, fruits and vegetables. Has also worked with sugars and syrups, and flavors and colors, and is likewise interested in production. REPLY BOX A-9106.

Industry or academic research position desired by individual with advanced degree in poultry science. Has worked in product development and quality control, and is experienced in meats, dairy, poultry, and eggs. Salary, $10,500. REPLY BOX B-0109.

Position in food production, research processing and quality control desired by graduate chemical engineer. Experience covers varied food chemical research, methodology; meat freeze dehydration, pilot plant to production, and chemical control analyses of military rations. Salary $7,500. REPLY BOX 881.

Position as senior bacteriologist desired by individual with advanced degree in this area. She is experienced in bacteriological and milk analysis and desires to work with milk, dairy products, frozen or canned foods. REPLY BOX B-0110.

Engineering research in the food industry interests chemical engineer with experience in this area. His product preference is coffee. Salary, $9,500. REPLY BOX A-3112.

POSITIONS AVAILABLE

Reply directly to ads BY BOX NUMBER (where indicated), including the company name of your current employer, via: Executive Secretary, Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois.

Eastern Food Canner needs Graduate Chemist or Food Technologist to direct Research and Development program. REPLY BOX 880.

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Real challenging opportunity for growth. Prefer a recent graduate or a young man with a few years' experience.

Confidential written or telephone inquiries welcomed by Gordon E. Morrison, Personnel Department.

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Mead Johnson & Company's continuing rapid growth has created new research positions at all degree levels in the development of nutritional food products.

Development of products meeting high standards of nutrition, acceptance, and stability. Scope of responsibility and salary will depend on experience and training. Liberal employee benefits and relocation allowances. Please send salary requirement and résumé to:

Manager, Technical Employment
Mead Johnson & Company
Evansville 21, Indiana

RESEARCH MANAGER

Opportunity for growth in medium sized food processing company in New York State. Conduct research and supervise the research functions including Product and Process Development and Improvement. Ph.D. or Master's degree in Chemistry, Food Technology or related science is required. Applied research experience necessary. Experience in foods preferred. REPLY BOX 887.

Leading citrus products manufacturer in Florida seeks Food Technologist, Research and Development. Requires applicant who has good technical background with creative ability. REPLY BOX 882.

SENIOR ENGINEER
FOOD PROCESSING

★

Engineer, with food processing background, for supervision of design, construction and installation of FREEZE DEHYDRATION equipment, and to perform customer liaison. Experience in freeze dehydration or refrigeration equipment helpful.

New England location. Reply in strict confidence, to:

BOX 891

RESEARCH PROJECT LEADER
Expanding dairy foods company has openings for personnel to perform independent research in Product Development and Improvement of dairy and snack foods. Recent graduates with Master's Degree in dairy or food technology preferred. All benefits including exceptional profit sharing—retirement plan. Relocation at Company expense to mid-western city. For information send complete résumé, including present earnings to BOX 889.

LABORATORY TECHNICIAN or CHEMIST: For production control, testing, development, for New Jersey Seasoning company. Kindly submit résumé. All replies held in strict confidence. REPLY BOX 888.

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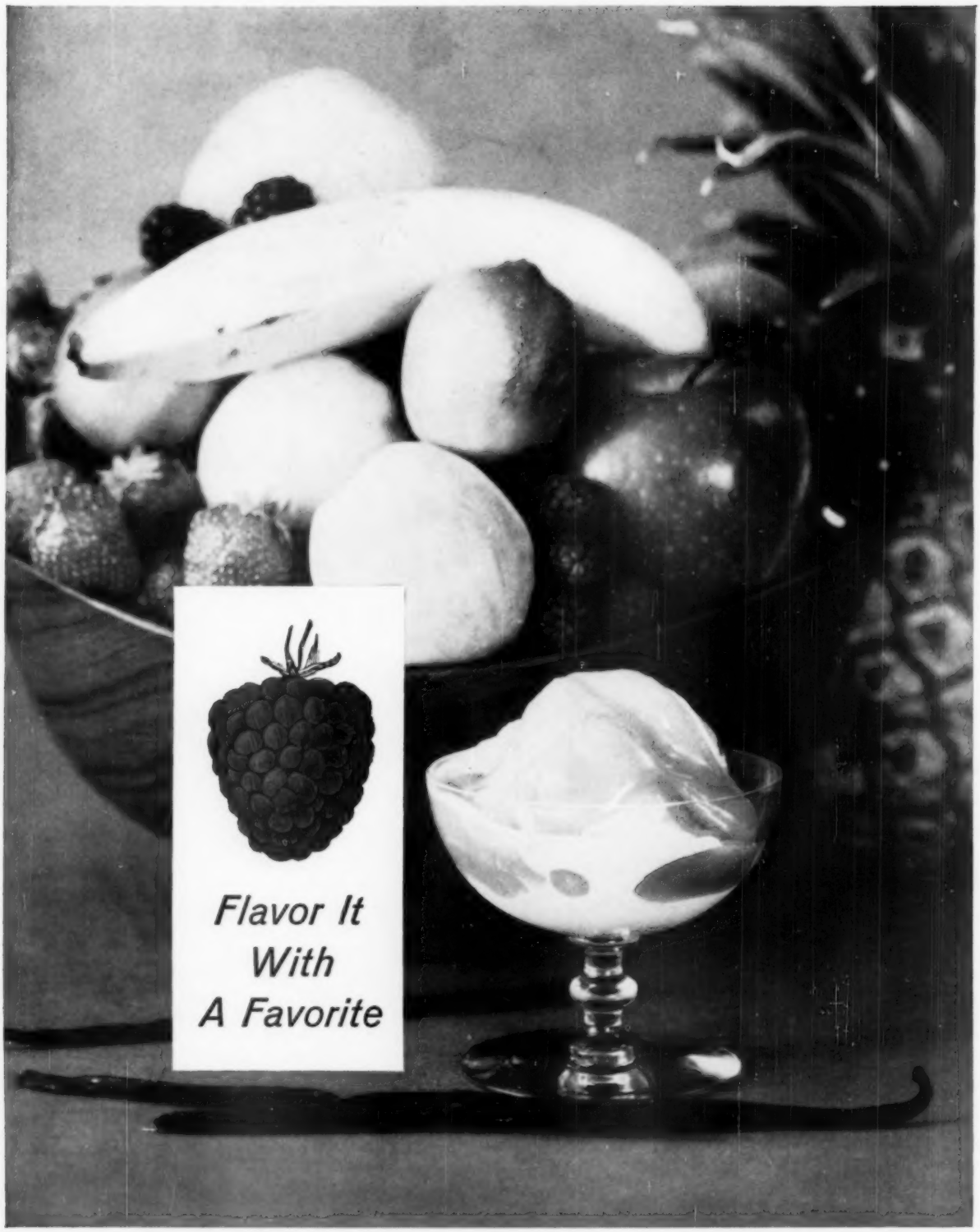

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